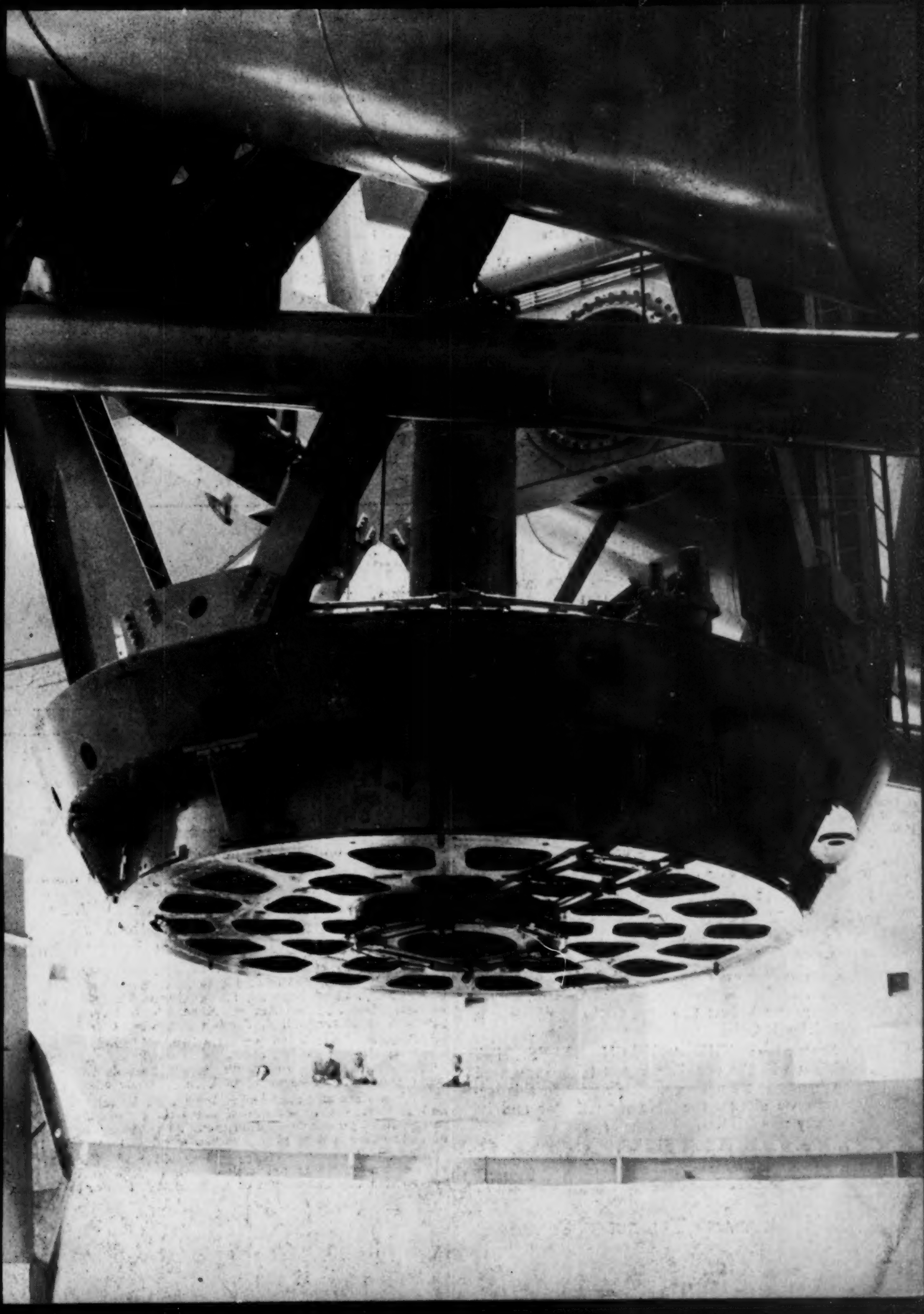


Planetarium Notes

ADLER PLANETARIUM

900 E. Achsah Bond Drive, Chicago 5, Ill. Wabash 1428

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.

STAFF: *Director,* Wagner Schlesinger. *Other lecturers:* Harry S. Everett, Albert B. Shatzel.

September: THE MOON.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa. Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

September: COLORS IN THE SKY. The story of the many colors seen in the evening, including those in stars and planets, in eclipses and rainbows and the northern lights.

October: COLUMBUS AND THE STARS.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

September: REASONS FOR THE SEASONS. The geometrical conditions of the rotation and orbital revolution of the earth will be explained, and the effects upon seasons, climate, and weather will be discussed.

October: MOON LORE — FACTS AND FANCIES ABOUT THE MOON.

GRIFFITH PLANETARIUM

P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m. Extra show on Sunday at 4:15 p.m.

STAFF: *Director,* Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

September: THE MOON. The appearance, physical constitution, motions, and phases of the earth's satellite are explained.

October: OUR STAR, THE SUN.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale.

September: THE 200-INCH TELESCOPE. What will the world's greatest telescope reveal when it is turned on the heavens? In this lecture we discuss the Palomar reflector and its many possibilities.

October: AUTUMN SKIES.

Sky and TELESCOPE

Copyright, 1948, by SKY PUBLISHING CORPORATION

CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER, *Managing Editor*

In Focus

OUR FRONT-COVER PICTURE of the lower end of the tube of the Hale telescope was taken during the recent gathering of astronomers on Palomar Mountain. The heavy hollow member of the polar axis is seen across the top of the picture. One of the polar axis braces hides the view of the declination axis region on the opposite side of the tube. On the edge of the lower ring of the tube is the motor for operating the mirror cover. The cover was closed at the time this picture was made, but it was opened later so the visitors could see the 200-inch mirror directly. The mirror cell, with its adjusting levers, is attached to the bottom ring of the main tube. Notice that these levers are not all in the centers of the openings. Corrections for controlling the mirror's figure to improve the star images have necessitated repositioning of the levers.

If the 200-inch disk were supported simply at the edge, its deflection at the center due to gravity would be about 2½ thousandths of an inch, which expressed in optical terms is 125 wave lengths of light. (The corresponding deflection for the 60-inch Mount Wilson mirror would be four wave lengths; for the 100-inch, 12 wave lengths.) Each of the 36 members in the system must support on the average some 850 pounds, and since the force actually exerted by each lever should be correct to 1/10 or 2/10 of one per cent for perfect results, it is not surprising that a few difficulties have been encountered. It will take many plates and considerable adjustment before the desired perfection is reached in the photographic images secured with the instrument.

Four visitors may be seen in the picture on the gallery of the dome on the opposite side of the chamber. In the lower left a portion of the telescoping observing platform for use at the Cassegrainian focus is visible.

On the back cover is Russell W. Porter's drawing of the lower end of the 200-inch tube, showing the mirror cell and the surrounding mechanism. Unlike the picture on page 269, this drawing gives one a view of the mirror and cell without the intervening beams which hide important details of the construction. Extending through the 40-inch hole in the mirror can be seen the shielding tube used to prevent extraneous light from interfering with

(Continued on page 279)

VOL. VII, NO. 11
WHOLE NUMBER 83

SEPTEMBER, 1948

CONTENTS

COVER: A view inside the dome of the Hale reflector, showing the lower end of the mirror tube. Photo by C. A. Federer, Jr. (See In Focus.)

BACK COVER: A drawing by Russell W. Porter of the mirror, supporting cells, and diaphragm mirror cover of the 200-inch telescope, Palomar Observatory, Calif. Courtesy, California Institute of Technology. (See In Focus.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscriptions: $3.00 per year in the United States and possessions, and to members of the armed services; Canada and all countries in the Pan-American Postal Union, $3.50; all other foreign countries, $4.00. Make checks and money orders payable to Sky Publishing Corporation. Canadian and foreign remittances should be made in United States currency. Circulation manager: Betty G. Dodd.

All notices of change of address must be sent three weeks in advance and accompanied by both old and new address, or we cannot make the proper change. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. For most efficient handling of your subscription, please return our bill form with your renewal payment.

Editorial and advertising offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited manuscripts unless return postage is provided by the author.

The dome of the Hale reflector, with the slit partially open.

The 200-Inch Telescope

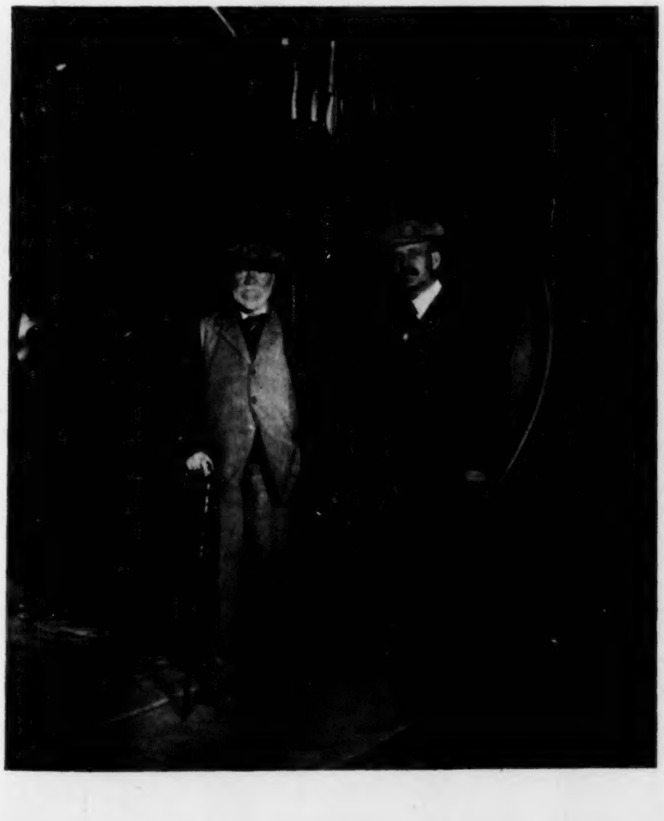
By Robert R. Coles, *Hayden Planetarium*

IN TRIBUTE to the great American astronomer, Dr. George Ellery Hale, whose vision and foresight made its construction possible, the 200-inch telescope has been named the Hale reflector. While we are awaiting the first observations from Palomar Mountain, it is interesting to speculate on the meaning of the great task that was culminated in its dedication. Why does man build such telescopes? How can these giant reflectors serve the hundreds of millions of persons who are not directly concerned with the science of astronomy?

The answer to the first question is to be found in the inherent curiosity of man. He is curious about the infinitely great and the infinitesimally small. He is desirous of learning just where he fits into the picture of creation and of becoming better aware of the interdependence of all nature. This is enough to inspire him to devise means of probing the outer limits of cosmic space on the one hand and the inner depths of the atom on the other.

But curiosity alone is not enough. Another trait with which man is endowed is imagination. Every scientist possesses this in large degree, and certainly George Ellery Hale had more of it than most men. He dreamed of the new 200-inch eye and visualized its tremendous possibilities when men of lesser stature were saying that it could not be done.

The Hale reflector will not in any way be a competitor of the telescopes now in operation throughout the world. With its ability to gather four times as much light, to penetrate twice the distance into the depths of the universe, and to double the theoretical resolving power of the 100-inch telescope, this new instrument will be busy for years just extending the programs its predecessors started. Other telescopes will continue to be built; such a large reflector as the 120-inch for Lick Observatory is already past the drawing-board stage. Schmidt cameras will be especially desirable, because with their short exposures they can search large areas of the heavens for objects the big reflectors can study in detail. Already the 18-inch has brought Palomar Mountain astronomical fame—together with the nearly completed 48-inch Schmidt it will play a very important role.



A picture made early in the 20th century of Andrew Carnegie (left) and George Ellery Hale, standing before the 60-inch reflector on Mount Wilson, then the "greatest telescope on earth." The other photographs with this article were taken by the editor.

One of the disadvantages of the yoke mounting of the conventional type is that the telescope cannot point to the north celestial pole. In the case of the 100-inch instrument, the maximum observable northerly declination is in the neighborhood of 65°, so there is a large inaccessible area around the north pole. Within that region are many stars that belong to the fundamental standard-magnitude sequence. The horseshoe mounting of the 200-inch permits it to reach these circumpolar objects, enabling direct comparison of magnitudes observed there with those of stars and galaxies in other parts of the sky. This

Dr. I. S. Bowen, director of Mount Wilson and Palomar Observatories, welcomes to Palomar members of America's two largest astronomical societies.

"Instead of a large spherical mirror with a central perforation, we used three relatively small mirrors so mounted that their centers of curvature fell together in one point. The hyperboloid was set up in such a position that one of its foci also coincided with the common center of curvature of the spherical mirrors. The light source was placed at the second focus of the hyperboloid. The method avoids the use of the big paraboloid and is therefore very convenient."

Dr. Anderson also mentioned that the coude flat, on account of its shape and relatively large size, was in many respects more difficult to make than any of the other mirrors in the telescope. It was, however, considered satisfactory in February, 1948.

Another speaker at the June gathering was Bruce Rule, also of Caltech, who described the engineering aspects of the great venture. He pointed out that the engineering designs were determined largely by the optical accuracy necessary. A comparable machine or other modern structure may safely deflect several inches under load, but the telescope must not deform in any position more than 1/16 of an inch, while the optics remain collimated and the mirror surfaces are held in their proper optical shape. There is very little relative deflection between the top and bottom of the tube. By recent tests, the total ex-

is especially important where observations of some of the galaxies near the north pole of the sky, such at M81 and M82, are concerned.

At present, the primary mirror and Cassegrainian mirror are installed and in operation, but the auxiliary mirrors of the coude system are in the process of installation. Altogether there are seven mirrors in the giant telescope:

1. The 200-inch mirror, a paraboloid having a focus of 55½ feet, or 666 inches.
2. The Cassegrain convex, 41 inches in diameter, hyperboloidal with an eccentricity of about 1.52, providing a focal length of 266 2/3 feet, or 3,200 inches.
3. Two coude hyperboloids, 36 and 32 inches in diameter, each of eccentricity 1.25 and producing a focal length of 500 feet, or 6,000 inches.
4. A coude diagonal plane mirror, 36 by 53 inches, to reflect the light along the polar axis to the coude spectrograph in a constant-temperature room directly south of the telescope.
5. Two auxiliary plane mirrors, 28 and 20 inches in diameter, for use with the coude diagonal when objects north of 50° declination are observed.

All of these mirrors are made of pyrex glass, and all except the two small flats are of the ribbed-back construction with internal supports. In his talk before the American Astronomical Society and the Astronomical Society of the Pacific, Dr. John A. Anderson, of California Institute of Technology, pointed out that the three convex hyperboloids were tested by a modification of Hindle's method.

This picture shows the south end of the polar axis and the upper end of the telescope tube, with the prime-focus cage. The end rings of the tube are 55 feet apart, and each ring is 22 feet in diameter.

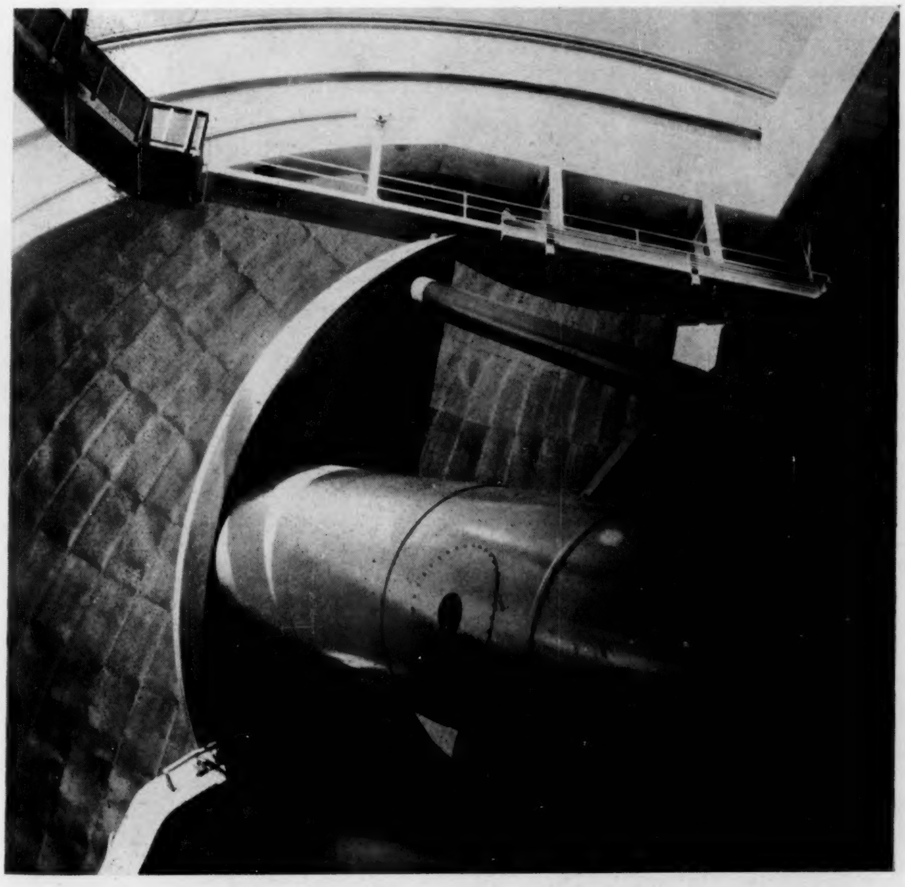
cursion of the prime-focus image for maximum telescope tube positions is within ½ millimeter, which is considerably smaller than tolerable. Final adjustments may even reduce this variation further.

The oil-bearing system of support for the polar axis, as well as many other mechanisms of this mainly automatic telescope, had to be designed to function correctly for a wide range of temperature, humidity, or position. The yearly average operating temperature range is from 20° Fahrenheit to about 70° Fahrenheit. The focal length of 55½ feet may change relative to the tube by about ¼ of an inch, because of differential expansion between the glass and the steel tube. To position correctly the prime-focus photographic plate, the change in length of one of the south tube I-beams is measured with respect to an invar bar having substantially a zero expansion coefficient. This change in tube length is transmitted to the prime-focus cage to the nearest 1/100 millimeter, allowing the observer to compensate for changes during long exposures.

The matter of temperature control in the observatory itself has been carefully studied, and the insulation panels filled with aluminum foil. For designing the dome, a copper model 36 inches in diameter was used in a variety of tests with direct loading, uniform hydraulic loading, and wind-tunnel loading, to allow for operation of the 60-ton crane in the observatory roof and for the effects of wind on the dome and slit. The outcome of these tests, together with the space requirements, resulted in the construction of a hemispherical dome 137 feet in diameter on top of a 27-foot-high cylindrical section. The dome is entirely of butt-welded 3/8-inch-thick steel plates which were disked to the proper radius in the shops. On each side of the shutter opening is a structural arch three feet wide and eight feet deep, terminating at the balcony horizontal plate girder which keeps the 1,000-ton dome circular. Rotational support is provided under this ring girder by means of 32 four-wheeled trucks which roll accurately on circular tracks that took five months to grind to proper accuracy and surface smoothness.

Mr. Rule went on to describe the unique manner in which the internal steel ribs extending from balcony level to the main arches of the dome provide a continuation of the air-venting space from the lower double walls of the stationary building. This construction permits the removal of absorbed heat from the external steel shell during the day, yet insulates the closed interior from temperature changes departing from the average night temperature. Air dampers in the lower walls provide for venting air either from inside or outside the building. Heat dissipation from lights, machinery, and people affects the time required to stabilize the optical components after opening the shutter at night, as well as badly affecting the internal dome "seeing." For this reason, all lighting equipment is ventilated to the dome air stack, as is the visitors gallery and the large machinery on the lower floor. Insulated dark rooms and laboratories are separately electrically heated and air-conditioned, and the exhaust fumes are transported underground away from the building.

The lower portion of the tube, with the mirror cover opened. Compare this picture with the back-cover drawing.

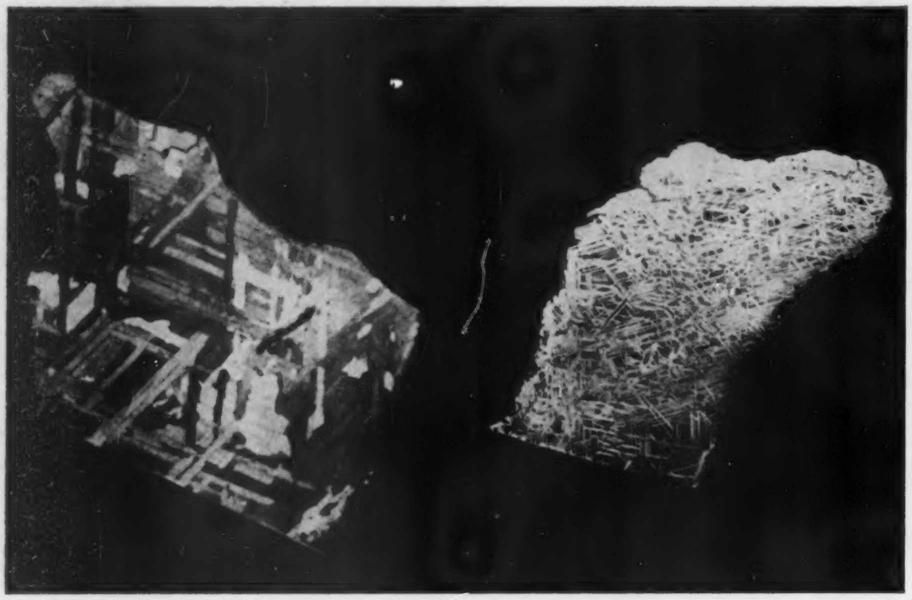


The horseshoe bearing at the north end of the polar axis has a diameter of 46 feet. This and the south polar bearing float on a film of oil 0.003 inch thick. Only 50 foot-pounds of torque are required to turn the 500-ton mounting in right ascension. The main tubular girders of the polar axis are each 10½ feet in diameter. In the upper left of the picture is visible the platform for entering the prime-focus cage. Note the catwalk in the upper dome.

What, if any, value will this great telescope have for Mr. John Q. Public? From the narrow monetary point of view it is doubtful if anyone will be wealthier because of the new reflector. But if man were to operate only those projects which benefit him financially, he would develop little culture. Fortunately, the discoveries and achievements of specialists in science, art, literature, and music, become accessible to everyone who is interested. In a very real sense this new Hale telescope is the property of all people. The pictures that it procures will be available to all who care to study them. Progress with the 200-inch will be interpreted and reported to the public through all our modern newscasting services.

New discoveries will come slowly from Palomar Mountain. Research of the type done at our observatories today is mainly by the study of carefully exposed photographic plates. Further care is required in the reduction of data and in its interpretation in the light of other observations. It may well be that this instrument, as did the 100-inch before it, will open up more problems which may seem to require even a larger telescope to solve.

TERMINOLOGY TALKS -- J. Hugh Pruett



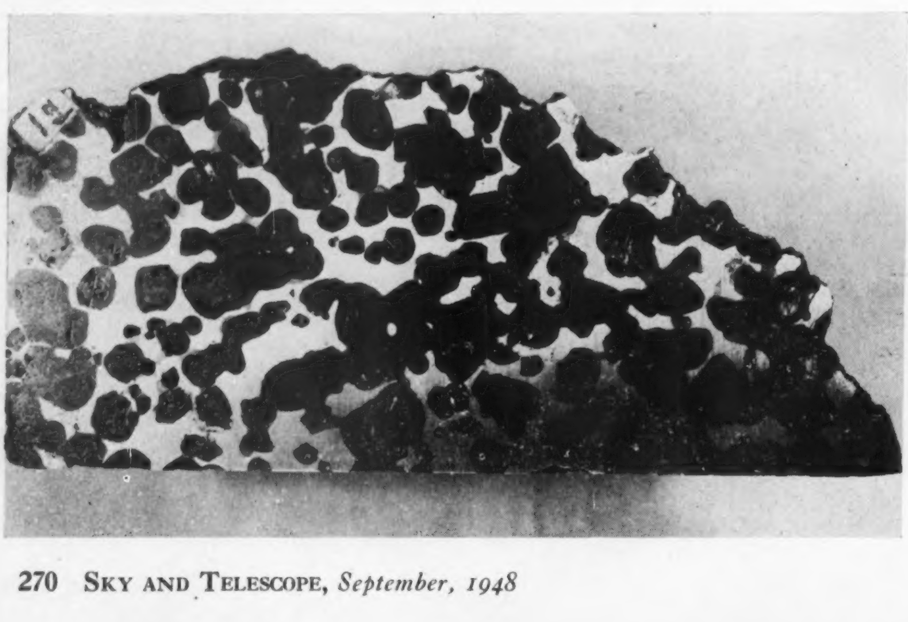
Etched faces of two iron meteorites: (left) Henbury, Australia, medium octahedrite; (right) Carlton, Texas, fine octahedrite.

Meteorite Specimens

Many of the natural history museums in large cities have on display splendid collections of meteorites, such as that at the Hayden Planetarium of the American Museum of Natural History in New York City. Five hundred and sixteen finds are housed in the American Meteorite Museum, about five miles north of the world-famous Canyon Diablo meteorite crater. (See *Sky and Telescope,* VII, 151, April, 1948). Meteoriticists everywhere are always glad to inspect and test specimens of metal or stone suspected of being meteorites. But meteorites are solid and heavy. Very light and porous materials, although correctly judged to have been at some time subjected to great heat, are not the real thing. They are very likely clinkers from a furnace or from the burning of a strawstack or the roots of a tree. The great majority of other "irons" and "stones" turn out to be commonplace geological specimens.

Fusion Crust

Freshly fallen meteorites are covered with a thin layer of material which is usually very dark in color, often black. This is the resolidified surface which was in a molten condition during the last of the visible flight. The exact appearance of this fusion crust depends upon the composition of the meteorite. In some kinds of meteorites the crust looks like a shiny coat of varnish; in others it is rough and scoriaceous.



Eclipses

That mythical dragon which on numerous occasions — in more-or-less ancient times — attempted to swallow the sun or moon and thus deprive earth dwellers of the beneficent glow of these luminaries, seems nowadays to be about "on his last legs." The supposed explanation of such darkenings as due to the gulpings of this sinister monster appears far too simple for modern astronomers. They would have us exercise our minds a little more intensely if we are thoroughly to understand the real causes of eclipses. In return we are spared the soul-racking fear which gripped the ignorant ancients at the occurrence of such harmless celestial displays.

From the original Latin and Greek, eclipse means "to fail," or "to leave out." This is fairly evident, for the light of the sun or moon does fail as far as we are concerned. In solar eclipses the sun's light diminishes or disappears because the moon, which is not self-luminous, gets between us and the sun. In the corresponding lunar phenomena, the earth blocks direct sunlight from the moon by passing between the sun and moon. Solar eclipses occur only at new moon; lunar eclipses only at full moon. An eclipse is described as *partial* if only part of the heavenly body concerned appears to darken; *total* if it is entirely "blacked out." There is a third type known as *annular,* but it is actually only a special form of a partial solar eclipse. The term is not from *annual,* meaning yearly, but from *annulus,* a ring. The moon's distance from the earth varies during a month from approximately 221,500 to 252,700 miles, so it has a greater apparent diameter at certain times than at others. The sun's distance also changes, but not by so large a percentage. Because of these variations, the moon at times appears wider than the sun and can completely cover the latter, if properly placed, and produce a total solar eclipse. But when the moon's apparent diameter is less than that of the sun, it cannot quite cover our central luminary and leaves the outer rim still shining in the form of a ring of light around the moon, whose dark side is turned toward us. This gives the beautiful annular, or ring, eclipse. An annular lunar eclipse is impossible with the present planetary arrangements, since the earth's shadow at the moon's distance is always almost three times as wide as our satellite's diameter.

A slab from the Springwater, Saskatchewan, stony-iron meteorite. The white portions of the photograph are silvery in the specimen; the darker portions are black and amber crystals of olivine.

NEWS NOTES

By Dorrit Hoffleit

R. A. MILLIKAN HONORED

A three-day symposium on cosmic rays was held at the California Institute of Technology in June, in honor of Dr. Robert A. Millikan's 80th birthday. Dr. Millikan has devoted 22 years to research on the nature of cosmic rays. Distinguished visitors at the symposium came from Ireland, England, France, and Latin-America, and included three American Nobel prize winners.

Among those presenting papers were Dr. G. D. Rochester, Manchester University, England; Dr. J. Robert Oppenheimer, Institute for Advanced Study, Princeton University; Dr. Bruno Rossi, Massachusetts Institute of Technology; and Dr. M. S. Vallarta, of Mexico. Dr. Rochester reported on isolating a meson with 1,000 times the mass of an electron (three to five times heavier than mesons formerly detected); while Dr. L. Leprince-Ringuet, of Paris, showed evidence obtained in the Alps of a meson with half the mass of a proton or, presumably, about 900 times that of an electron.

Dr. Millikan recounted his theory that cosmic rays are produced through an atom-annihilation process when atoms in interstellar space meet and destroy each other. Other scientists present held different views. Dr. Vallarta discussed a new theory showing how the rays might be initiated by electromagnetic storms in the sun and stars.

OSLO MEETING

The International Union of Geodesy and Geophysics was scheduled to hold its meetings at Oslo, Norway, on August 17-28. The agenda for the sessions of the Association of Terrestrial Magnetism and Geodesy lists over 100 papers, reports, and topics for discussion. Many will be of interest to astronomers, especially to those concerned with solar and meteoric phenomena. Dr. John A. Fleming is chairman of the committee on the study of the relationship between solar activity and terrestrial magnetism, while L. Vegard led a discussion in which 11 papers were presented covering solar eclipse observations, radio fade-out effects, and the problem of the origin of ionized regions of the atmosphere. In fact, a great many of the papers dealt with both theoretical and observational aspects of the ionosphere.

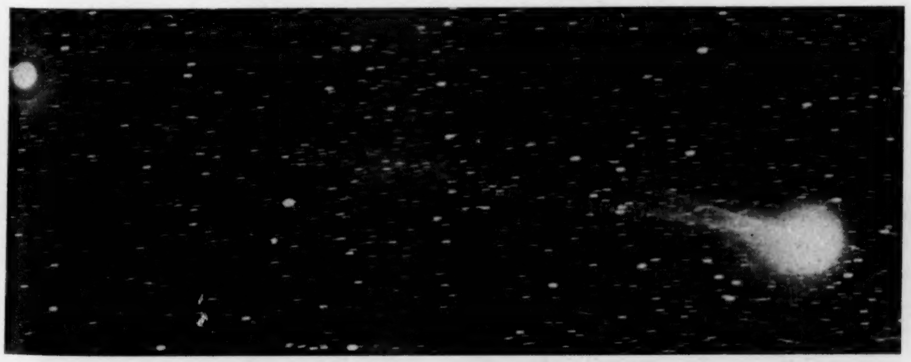
C. Stoermer is chairman of the auroral committee, and S. Chapman reported on international collaboration for promoting the study of the influence of the moon on geophysical phenomena. Jointly with the Association of Meteorology there were discussions on the physics of the upper atmosphere, including work on auroras, meteors, and radio phenomena. At least three papers dealt with studies of meteors involving radar or radio instrumentation.

AAAS CENTENNIAL

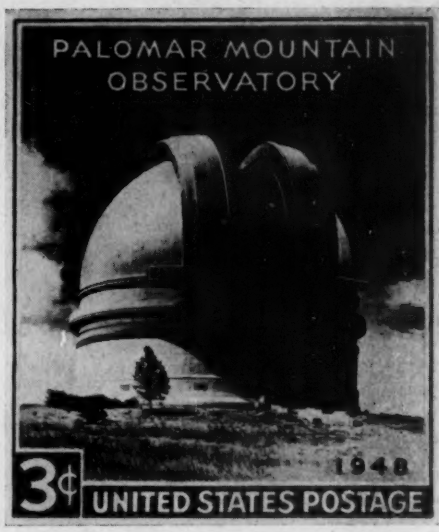
A meeting celebrating the 100th anniversary of the American Association for the Advancement of Science will take place in Washington, D. C., September 13-17. There will be 15 symposia presented, with three speakers each. One symposium is on problems of the earth's gaseous envelope, its theme described by Dr. D. H. Menzel, of Harvard Observatory, in *Science,* for June 18, 1948. Ten evening lectures will be given, the first by Dr. Harlow Shapley, retiring president of the AAAS, on "One World of Stars," September 13th.

Instead of the usual AAAS exhibition, there will be tours and visits to some 40 educational and scientific institutions in the Washington area.

COMET HONDA-BERNASCONI (1948g)



This picture of Comet Honda-Bernasconi was taken at Lowell Observatory on June 13, 1948, by Henry L. Giclas, with the 13-inch photographic telescope. See page 221 of this volume for details of the discovery of this comet, which has faded to 12th magnitude or fainter. It passed perihelion on May 15th, at a distance of 1/5 astronomical unit, but is now rapidly receding.



ATTENTION ASTRONOMERS AND PHILATELISTS

Postmaster General Jesse M. Donaldson has announced a new 3-cent postage stamp of particular interest to astronomer-philatelists. The first stamps of the authorized 50 million initial printing will go on sale at Palomar Mountain on August 30th. Samuel R. Young, Washington, D. C., amateur astronomer and executive assistant to the postmaster general, will represent the latter at the observatory ceremonies when the first stamp goes on sale.

Anyone desiring first-day cancellations may send not more than 10 self-addressed envelopes to Postmaster, Palomar Mountain, Calif., with postal note or money order to cover the cost of the stamps to be affixed.

LINK OBSERVATORY GIVEN TO INDIANA UNIVERSITY

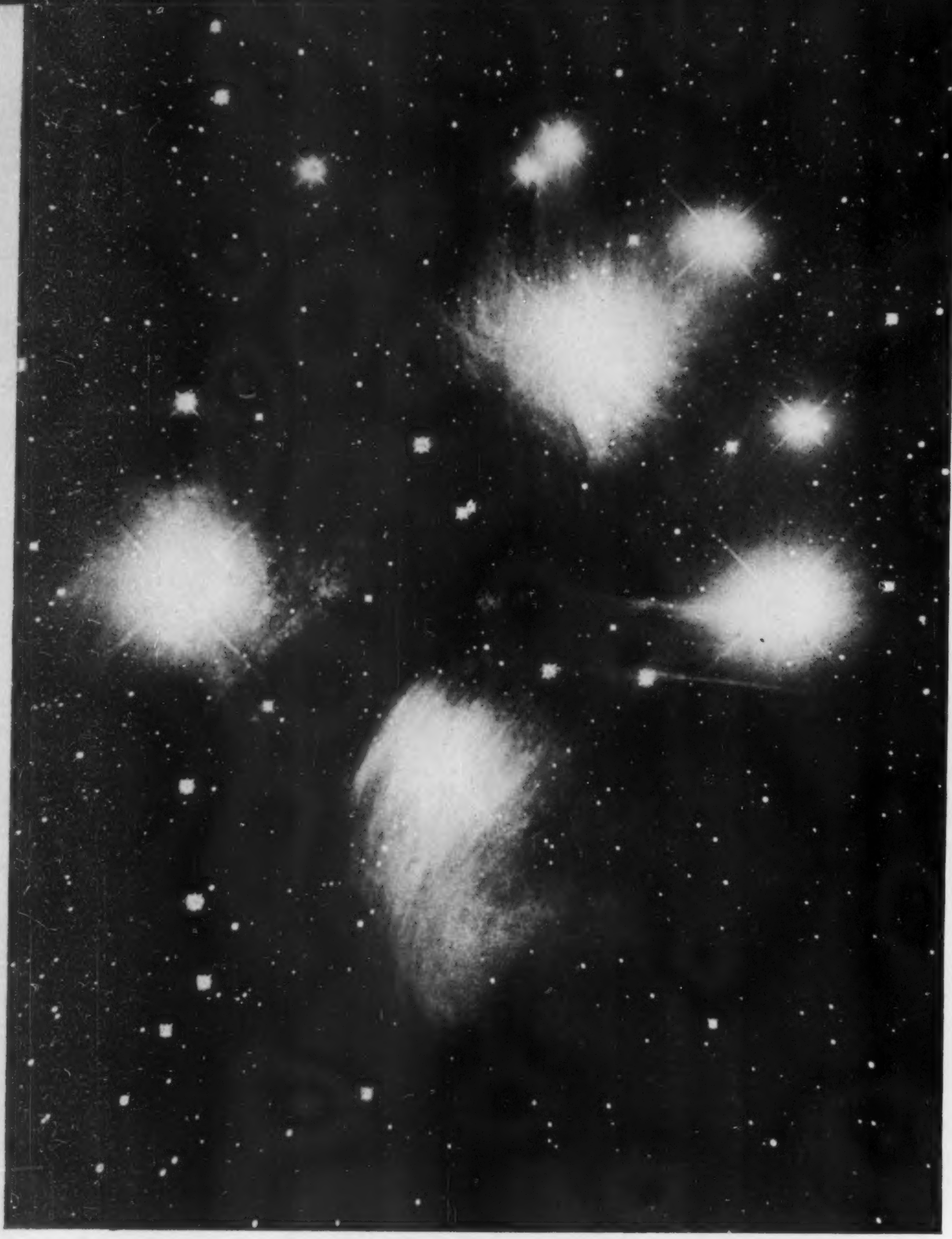
The Goethe Link Observatory, largest in Indiana and situated 25 miles south of Indianapolis, has been presented to the astronomy department of Indiana University by Dr. and Mrs. Goethe Link, of Indianapolis. In addition, the donors have established a foundation for scientific research to furnish an income to maintain the observatory.

A 36-inch reflector on a two-pier cross-axis mounting is the principal instrument at the Link Observatory. The dome is 34 feet in diameter. Present equipment includes a photoelectric photometer, and it is planned to add a spectrograph. A 10-inch, wide-angle camera is to be installed in a separate building, to carry on asteroid observations.

The Indiana University department of astronomy at Bloomington, directed by Dr. Frank K. Edmondson, has worked considerably with the Link telescope since its completion in 1939. Of chief importance have been observations of galactic clusters by Dr. James Cuffey.

Early Chapters in the History of Stellar Evolution

By K. E. Edgeworth



Nebulosity in the Pleiades. This picture was taken with the 24-inch reflector of Yerkes Observatory by G. W. Ritchey. The exposure was 3½ hours. Yerkes Observatory photo.

PART II

Third Hypothesis: The Formation of Filaments

Our attempts to solve our problem on the basis of spherical condensations having proved unsuccessful, it becomes necessary to approach the matter from a somewhat different angle.

To begin with, it may be remarked that we are called upon to discuss the question of stability in a thin sheet of material, and that this constitutes a problem in two dimensions rather than three. When waves are formed on the surface of a sheet of water, it is noticeable that, in general, the waves take the form, not of humps, but of long continuous lines. If a disturbance of this character is a prelude to gravitational instability, then the condensations formed may be expected to be in the shape of filaments or rings rather than in the shape of spheres or spheroids.

Again, if the movement of the scattered material in the neighborhood of an embryo condensation is examined it will be found to be significant.

Let the center of the disk be taken as origin. Let the point C (o,r) be the center of an embryo condensation, and let P $(x, r + y)$ be a point close to C, that is to say, let x and y be small compared with r.

Let V denote the orbital velocity at C, with components V, o. The orbital velocity is not constant, but may vary with r; let the rate of change be denoted by dV/dr. Then the orbital velocity at P is $V + ydV/dr$, and its components are $V + ydV/dr, xV/r$. The components of velocity of a particle at P referred to the center of the condensation at C are therefore $ydV/dr, xV/r$.

The actual value of dV/dr depends on the distribution of mass in the galaxy, but, generally speaking, when there is some central condensation, dV/dr is negative and less than V/r. Let us put it equal to $-\frac{1}{2}V/r$, so that the components of velocity at P are $-\frac{1}{2}yV/r, xV/r$. The results derived from this formula are shown in Fig. 1. The large arrows indicate the orbital velocity of the local system about the center of the galaxy, and the small arrows, the local velocities relative to the condensation. It will be observed that the material along the line XX is moving inwards, and it is clearly more probable that condensation, when it occurs, will take place in this direction rather than in any other.

We are led by considerations of this sort to the hypothesis that a rotating disk of gas, when it becomes unstable, will probably break up into a number of long parallel filaments, and this inference receives some support from observation. When clouds of interstellar material are illuminated by stars, as in the region of the Pleiades, large-scale photographs show a set of regularly spaced streaks.

The conditions in the two cases are different, and the filaments postulated in the present theory are much larger than the streaks appearing in the photographs, but the tendency to form streaks rather than spherical condensations provides important confirmation of the theory.

The size of the filaments is determined by considerations of the kind already discussed in the case of spherical condensations, that is to say, the diameter cannot be less than a certain minimum. This minimum is of the order of 5×10^{19} centimeters, or one thousandth part of the diameter of the sun's orbit about the center of the galaxy. The corresponding density is 2.5×10^{18} grams per cubic centimeter. If it is assumed that the length of the filament was, say, five times its original diameter, then its total mass would be that of about 10 million stars.

Once formed, a filament is gravitationally unstable in a radial direction, so that it continues to shrink upon itself. It is also longitudinally unstable, but to a lesser extent. The longitudinal instability is important because, although it is at first insufficient to cause a complete rupture, it destroys the initial

uniformity of the filament and makes the distribution of mass very uneven.

In the early stages the material was so tenuous that it was completely transparent, and there was no obstacle to the escape of heat, so that contraction proceeded unchecked. Ultimately, however, the increase of density which was associated with the contraction rendered the material opaque, the escape of heat was retarded, and the process of contraction slowed down. Longitudinal instability then intervened and the filament broke into fragments. Finally, these fragments contracted upon themselves to form the actual stars. The radial contraction of

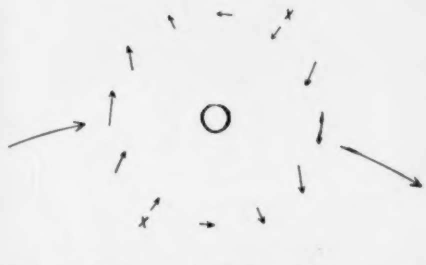


Fig. 1. Orbital and local velocities tend to produce condensation along XX.

the filament, from the time it was first formed until it broke up, was probably of the order of one in a hundred thousand.

It will be remembered that the first condition that a theory of stellar evolution is called upon to meet is that the initial condensations must be sufficiently large for the process of contraction to begin. The filament theory satisfies this condition.

We now turn to the question of rotation. It has just been mentioned that the radial contraction of the filament may have been of the order of one in a hundred thousand, but contractions of this order cannot be illustrated in a diagram. To explain the point let us compare a sphere undergoing a radial contraction of 1:4, corresponding to a contraction of volume of 1:64, with a filament undergoing a radial contraction of 1:8, corresponding to a similar change in volume.

In the case of a spherical contraction, the original sphere contracts to form a new sphere of one quarter the original diameter, as shown in Fig. 2. Angular momentum is proportional to the area swept out in unit time, so that a radial contraction of 1:4 involves a reduction of the area swept out of 1:16 and an increase of 16 times in the speed of rotation.

The filament, on the other hand, as shown in Fig. 3, shrinks to one eighth of its original diameter, but the length remains practically unaltered. Since the angular momentum depends on the length of the filament and is not affected by the radial contraction, the speed of rotation remains substantially unchanged. Ultimately, when the filament breaks up, the angular momentum assumes the form of relative motion of the different fragments and the rotation of the fragments themselves remains quite small. In this way the filament theory entirely escapes the difficulty experienced by the former theories in explaining the low angular momentum of the sun. In fact, the angular momentum of the sun, as calculated from the filament theory, is considerably less than the angular momentum of the sun at the present time.

Finally we come to the question of the survival of the intermediate structure, which, in this case, is the filament. In our earlier theory we met the difficulty that a cluster of stars, once formed, would persist to the present day, but no such difficulty arises in the case of the filament theory. In the time required for two or three revolutions of the galaxy the main structure of the filament would have disintegrated.

It would not be correct to say, however, that the filament would leave no trace of its existence. It has already been mentioned that longitudinal instability would develop while the filament was still contracting, and that this would result in local increases in density of very varying character. The final result would be to produce just that combination of single stars, binary stars, and multiple systems which is actually observed.

It will thus be seen that our third hypothesis removes the various difficulties encountered in the earlier theories, but this is not all. It offers a solution to an entirely different problem which has long been a puzzle to astronomers.

Fig. 2. (Right) Contracting sphere.

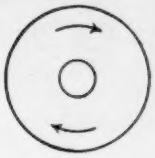
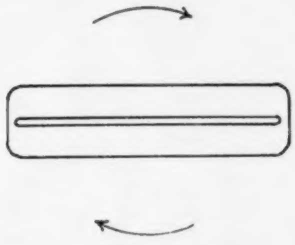


Fig. 3. (Below) Contracting filament.



Angular Momentum in the Solar System

The hypothesis that the solar system was evolved from a rotating cloud of gas is usually associated with the name of Laplace, and there is no doubt that he made some very relevant and very important contributions to the theory of the subject. His views were amplified and expanded by his successors, and difficulties have developed for which Laplace has been held responsible. But it may well be suggested that Laplace has been misunderstood, and that subsequent writers have attributed to Laplace opinions which he never actually expressed. However, as Kipling would say, that is another story.

The point is this. The angular momentum of the solar system is almost entirely due to the orbital motion of the major planets; the angular momentum of the sun, due to its rotation, is less than three per cent of the whole. A contracting cloud of gas is necessarily arranged so that the angular momentum per unit mass at the equator is greater than it is near the center, but no conceivable arrangement of material and angular momentum in the original cloud could possibly lead to the distribution of angular momentum in the solar system as it actually exists.

The only way out of the difficulty is to assume that the material forming the sun and the material which forms the planets were derived from two different sources. This consideration has led to the development of theories of the collision type, but such theories are open to very grave objections, for example:

1. The probability that a collision, or a close encounter, will occur in the time available is so slight that such theories lack plausibility.
2. The filament of material which might be detached from one or other of the stars would be at a high temperature, and would be of less than stellar mass. As we have already seen, in discussing the formation of the stars, such a filament would not condense but would be dissipated into space.
3. The angular momentum of the detached material about the sun would not be large enough.
4. Collision theories cannot explain the low angular momentum of the sun, and it is this, rather than the large angular momentum of the planets, that really needs explanation.

These are formidable objections, and collision theories, although they have survived until recently in default of anything better, have never appeared to be very satisfactory.

The filament theory of stellar evolution provides a very simple and perfectly straightforward solution to the problem. Following the condensation of the stars, as already described, it may be supposed that a certain amount of material escaped the original cataclysm and remained scattered in space. This material would be captured by the stars and would be available to form the planets. It may be supposed that the region from which the material was captured was roughly spherical in shape, so that its angular momentum can be calculated in the manner already described in con-

(Continued on page 277)

Amateur Astronomers

Northwest Regional Convention at Portland, Oregon

At the June convention of the Northwest region of the Astronomical League, according to *The Observer* of the Yakima Amateur Astronomers, the following were elected regional officers: James H. Karle, Portland, chairman; Edward J. Newman, Yakima, vice-chairman; Margaret V. Edgar, Portland, secretary; and C. G. Benson, Portland, treasurer. From Wisconsin, Dr. C. M. Huffer, chairman of the North Central region, attended the convention of the Northwest region.

Following the turkey banquet served on Saturday evening, June 12th, to over 50 delegates and guests, Dr. R. M. Petrie, of the Dominion Astrophysical Observatory, discussed "Some Problems of the Motions of the Stars" before a large audience in the Central Library in Portland.

Several sessions for papers and a business session were included on the program. The convention exhibit was set up in the science building. The concluding features of the convention were a tour of the Lewis and Clark College campus and a visit to the 12-inch Evans telescope, which has recently been donated to the college by Mrs. Guy Evans, widow of the amateur who built the instrument.

METEOR SOCIETY REGIONS

The organization of the western portions of the United States for the purpose of gathering reports of meteor observations for the American Meteor Society is now fairly complete. Dr. Charles P. Olivier, Flower Observatory, University of Pennsylvania, president of the society, has announced that the states of Colorado, Utah, Arizona, and New Mexico form a region under the directorship of Dr. Lincoln La Paz, head of the Institute of Meteoritics, University of New Mexico, Albuquerque.

States to the west are directed by Dr. J. Hugh Pruett, General Extension Division, University of Oregon, Eugene, Ore., who has sectional assistants in:

Southern California: John Buddhue, chemist, 99 S. Raymond Ave., Pasadena 2, Calif.

Northern California: Dr. Earle G. Linsley, research associate in astronomy, California Academy of Sciences, San Francisco, Calif.

Nevada: Professor G. B. Blair, professor of physics and astronomy, University of Nevada, Reno, Nev.

Oregon: Phil F. Brogan, city editor of the **Bulletin** and chairman of the Oregon Geographic Board, Bend, Ore.

Washington: Walter Oberst, science instructor, High School, Pasco, Wash.

Idaho: Miss Eleanor Sandmeyer, Buhl, Idaho.

All western amateurs who observe meteor phenomena or who learn of observations of bolides and fireballs by others should report available information to the nearest of the above-named persons as soon as possible. Local newspapers should be watched for requests for reports and assistance given in collecting them, if one wishes to increase our knowledge of meteoric phenomena.

THIS MONTH'S MEETINGS

Chicago: "The Planet Mars: Another World," is the title of the lecture to be given by Dr. Gerard P. Kuiper, of Yerkes and McDonald Observatories, at the regular meeting of the Burnham Astronomical Society on Tuesday, September 14th, at 8:00 p.m. in the Chicago Academy of Sciences.

Columbus: Dr. J. Allen Hynek, of the Ohio State University's McMillin Observatory, will describe his recent visit to Mount Palomar at the first fall meeting of the Columbus Astronomical Society. The meeting is on September 28th at McMillin Observatory. The lectures on elementary astronomy preceding the regular monthly meetings will be continued this coming season.

Indianapolis: Meeting at the Johnson Observatory on September 5th, the Indiana Astronomical Society will hear a lecture by Emsley Johnson on "Knowing the Stars."

Kalamazoo: A potluck supper will be held by the Kalamazoo Amateur Astronomical Association on September 11th, 6 o'clock at Wolf Lake. Burke Hazelrigg will speak on "Finding Our Way Around the Sun," and Clayton Howe will show pictures.

Los Angeles: On Tuesday, September 14th, Dr. Walter Baade, of the Mount Wilson Observatory, will discuss "Galaxy and Stellar Populations," before the Los Angeles Astronomical Society, at 7:45 p.m. in the planetarium of the Griffith Observatory.

LETTERS

Sir:

During the last few months here at General Electric, we have been doing some experimental work with the infrared image tubes that are used in the U. S. Army's sniperscope. These tubes are made to change an infrared image into a visible light image. We have discovered that if one of these tubes (Farnsworth 1P25) is mounted at the prime focus of a telescope, the planetary and moon images are seen with a good deal more steadiness, as this tube allows us to observe visually in the infrared region, as the infrared light is disturbed less than the visible light.

We hope some of the amateur astronomers and professional men give this scheme a further trial, as the tubes should be available on the surplus market.

C. G. BACON
General Engineering and
Consulting Laboratory
General Electric Co.
Schenectady 5, N. Y.

Sir:

"In the seventeenth century it was a favorite device to make a clock show sidereal time as well as mean solar time. The length of the sidereal day is to the mean solar day as 0.99727 is to 1, and various attempts have been made by trains of wheels to obtain this relation — but all are somewhat complicated."

Coming upon this statement in the **Encyclopaedia Britannica** (11th Ed., Vol. 6, page 551), I thought that what may have seemed complicated a few hundred years ago may not appear to be so today, and I determined to find one or more gear ratios which would give sidereal time correct to 1/20 of a second per year or better. I used the length of the tropical year for 1950 as my starting point and sought two numbers **M** and **N** such that **M** is to **N** as 366.24219572 is to 365.24219572. Surprisingly enough, up to about 620,000, which was as far as I went, there are more than 400 such number pairs within the degree of accuracy of 1 part in 633,-000,000 which I had set for myself, but only a few of these are usable. This is because the nature of the problem also requires that neither **M** nor **N** be prime numbers nor contain prime factors larger than about 1,000, as the making of gears with more than this number of teeth is not practical.

The smallest number pair found to meet these conditions was 57,500 and 57,343. The first of these numbers is the product of 250 and 230, while 57,343 is the product of 143 and 401. For ease of presentation, this may be written as: $57{,}500/57{,}343 = 250 \cdot 230/143 \cdot 401 = 23 \cdot 25 \cdot 100/11 \cdot 13 \cdot 401$.

A sidereal clock driven by this gear arrangement would gain 0.037268 sidereal seconds per year or one second in about

(Continued on page 283)

Tennessee Amateur Dies

Latimer J. Wilson, vice-president of the Barnard Astronomical Society at Nashville, Tenn., died on May 17th in his 70th year. He was an instructor at Watkins Institute, and succumbed to a heart attack while preparing to teach a class. He was still very active in his astronomical pursuits.

A native of Nashville, Mr. Wilson did much to popularize astronomy in that city, while his contributions to astronomical publications came so regularly during most of his life that his name was well known to most amateurs and professionals. He consistently made visual observations of the moon and planets, and took excellent photographs of many kinds of celestial objects. His latest experimentation was in the taking of stellar spectra with war-surplus prisms.

He was trained to be a musician and artist, turned to writing fiction and then science, was associate editor of *Popular Science* magazine from 1919 to 1922, and added aeronautics to his interests in later life. For a time in the '30's he was director of the Chattanooga Observatory.

American Astronomers Report

Here are highlights of some papers presented at the 79th meeting of the American Astronomical Society at Pasadena, California, in June. Complete abstracts will appear in the Astronomical Journal.

Radio and Sunspots

IF THE ANTICIPATED decline in sunspot numbers during 1948-1949 comes true, short-wave radio communications can be expected to improve during daytime hours at a frequency of five megacycles, but to become poorer both day and night at 10 megacycles. Results from data obtained at the Cosmic-Terrestrial Research Laboratory of Massachusetts Institute of Technology were reported by Dr. Harlan T. Stetson.

He showed records of reception at Needham, 373 miles from Beltsville, Md., where is located the National Bureau of Standards transmitter for the standard frequency and time-signal waves which Dr. Stetson uses for his observations. The period of his observations covers the rise in sunspot activity from minimum about 1944 to near maximum, the latter occurring in May, 1947. It is well known that at maximum sunspot activity there is more ionization of the radio reflecting layers in the earth's upper atmosphere, but this change does not affect all wave lengths similarly, as Dr. Stetson's results show.

For nighttime reception, from 10 p.m. to 2 a.m., five-megacycle energy increased steadily with sunspots to a maximum value corresponding to a sunspot number of 110. Thereafter a fall in field intensities was observed as the sunspot number rose to a value of 150, the maximum of the mean monthly sunspot number encountered. This decline in field strength Dr. Stetson explains by the attenuation of the waves by the increased ionization of the lower layers through which the nighttime wave must pass in its propagation from Beltsville to Needham. Just what will happen to the nighttime reception of the five-megacycle frequency as sunspots decline remains to be seen.

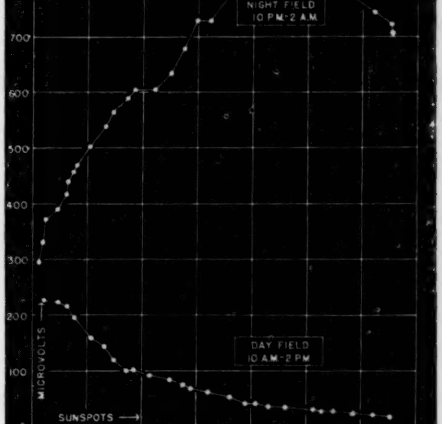
For daytime reception, the five-megacycle band gave poorer results as sunspots increased. For 10 megacycles, however, reception improved considerably during both daytime and nighttime hours. This is how one may predict worsening reception conditions, at least for propagation distances of about 400 miles, as sunspots decline again. At the extreme maximum of solar activity, however, the nighttime 10-megacycle wave also showed a decline in field strength similar to that of the five-megacycle wave, but up to a sunspot number of 144 it had increased.

As a result of Dr. Stetson's work, he states that for practical purposes the continuous time signal from the National Bureau of Standards (Station WWV) can best be received during high solar activity in the daytime on the 10-megacycle frequency, whereas during the night hours much greater facility will be had by using five megacycles — at least for reception of some 400 miles.

As a corollary to this work, Dr. Stetson reported on current results with his program of many years' duration: the reception at Needham of the commercial broadcasting station WBBM, Chicago, 851 miles away. During the recent sunspot increase this reception has steadily and strikingly become worse, so for the normal broadcast bands the decline in sunspots now occurring can be expected to bring improved radio conditions.

Magnetic Fields in Stars

CERTAIN STARS of spectral class *A* contain in their spectra lines of the metallic elements in addition to the normally prominent lines of hydrogen. Some years ago, Dr. W. W. Morgan, of Yerkes and McDonald Observatories, concluded that "some physical factor other than temperature and surface gravity is concerned in the production of the spectra of the *A* stars." It is in this class of star that the strongest stellar magnetic fields have been found within the past two years, and Dr. Horace W. Babcock, of Mount Wilson Observatory, believes the conclusion is practically inescapable that the missing physical factor is the magnetic field.



The intensity of the WWV five-megacycle signal as received at Needham during the recent increase in sunspot numbers. Plotted from 12-month running means of monthly values, 1945-1947. Diagram by Cosmic-Terrestrial Laboratory.

This is but one case of the application of Dr. Babcock's work on the magnetic intensification of absorption lines in stellar spectra. In a magnetic field of a few kilogauss, the splitting of a line, initially of moderate intensity, into the several components of the Zeeman pattern may markedly increase its width without requiring any change in the number of atoms involved in producing the line. The degree of intensification depends primarily upon the strength of the magnetic field of the star, upon the number and separation of the Zeeman components of the line as compared to its thermal Doppler width, and upon the initial intensity of the line.

The lines of ionized europium in the magnetic variable star HD 125248 provide a striking example of magnetic intensification. The predicted pattern of the Eu II line at wave length 4205 angstroms has 23 components uniformly distributed over a range 2.75 times as wide as a normal Zeeman triplet. In HD 125248, the Eu II lines vary enormously in intensity with a regular period of 9.295 days, and at Eu II maximum the varying polar magnetic field of the star reaches the extraordinary value of about 7,800 gauss, the strongest magnetic field known in nature. The overall width of the 4205 line in HD 125248 at Eu II maximum is about 0.35 angstrom, compared to only 0.023 angstrom for the thermal Doppler width. The rotational broadening of the star's lines is negligible.

In closing his paper, Dr. Babcock pointed out that although rapid strides are being made in studying the magnetic fields in the sun and other stars, such things as variations in magnetism are as yet unexplained, and that the major problem of the source of the field itself remains unsolved.

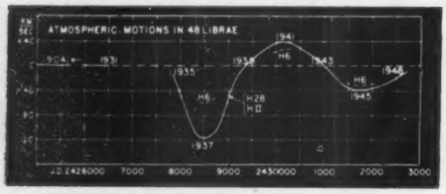
A Damped Oscillation

FROM 1904 to 1931, spectrum lines formed in the atmosphere of the naked-eye star 48 Librae (spectral type *Ae*) had yielded a nearly constant velocity which presumably was that of the star as a whole. In 1935, displacements of the lines showed that an outward surge of the atmosphere was under way. Dr. Paul W. Merrill, of Mount Wilson Observatory, reported that this surge continued until 1939, with a maximum outward velocity of about 110 kilometers per second in 1937. If through-

out this interval the spectrum lines were produced by the same atoms, these atoms would have traveled outward about 50 astronomical units. It is much more likely that the lines were produced by a succession of atoms passing through a fixed (or nearly fixed) zone of absorption above the star.

From 1939 to 1943, the motion was inward with a maximum velocity of 40 kilometers per second in 1941. Since 1943, as the velocity curve shows, the motion has again been outward, but its velocity is now gradually decreasing. Hence it appears that the disturbance which occurred about 1934 produced an oscillation subject to strong damping.

Most of the spectrograms show progressive changes in velocity from line



The fluctuations of spectral line positions in 48 Librae. Diagram from Mount Wilson Observatory.

to line along the Balmer series of hydrogen lines. These changes are probably related to pressure and thus to the height above the star's photosphere at which the lines are produced. On this hypothesis, the results indicate that the net *acceleration* in the atmosphere is outward whether the *velocity* is outward or inward; and that the acceleration has diminished gradually since 1937.

Meteor Orbits

AS A WORKING HYPOTHESIS concerned with the general problem of the origin of the solar system, Dr. Fred L. Whipple, Harvard College Observatory, prefers to associate generically all or nearly all of the brighter visual meteors, and those bright enough to be photographed, with comets rather than with meteorites and asteroids. His preference in this matter was expressed at the conclusion of his paper, in which he reported that the orbits of 45 photographic meteors have been determined with considerable precision by Harvard's two-station rotating-shutter method.

Of these 45 meteors, 28 were found to belong to one of seven meteor showers, nine meteors were sporadic, and eight more were uncertainly associated with showers.

Dr. Whipple has related his findings of the elements of meteor orbits with the same characteristics of the orbits of comets, with meteorites in space, and with asteroids. He believes that bright meteors are the debris of comets rather than that they are simply small meteorites or asteroids. His preference is based upon many cases of obvious association; similarities in orbital characteristics among sporadic meteors, shower meteors, and short-period comets; the fact that meteorite falls suggest little or no shower association; and the selective elimination of small asteroidal particles as time passes.

With his associate at Harvard, Miss Frances W. Wright, Dr. Whipple also reported on October meteor showers. In the month of October from 1891 through 1947, 147 meteors (179 trails) have been photographed on Harvard plates. Of these meteors, 46 per cent have been identified as belonging to showers, and 54 per cent are sporadic. Miss Wright has discovered a new shower active from October 2nd to 10th with maximum on October 6th, its apparent radiant in Pegasus. The Orionids, a well-known shower, account for about 20 per cent of the October meteors. An identification of the shower with Halley's comet remains reasonable but unproven.

The meteors observed at Harvard over such a long period are a result of the patrol-camera survey constantly maintained at that institution. Small, wide-field cameras take long exposures to record any astronomical event, such as the flight of a meteor. From two stations about 25 miles apart, if the same meteor is photographed, calculations of its height can be made. If the cameras are equipped with a rotating shutter to chop the meteor's trail into short lengths, the velocity of the meteor can be determined and its orbit in space computed.

Stars and Nebulosity

BOMBARDMENT of small, cool stars in clouds of interstellar nebulosity by the dust particles of the clouds appears to supply just the required amount of energy to make peculiar bright lines in the spectra of these stars. On the other hand, very luminous blue and white stars in such a dark nebula are known to repel the dust by the action of the outward pressure of their intense light, so that the particles of the cloud cannot fall into the atmospheres of these bright stars.

One result of recent work by Drs. Otto Struve and Mogens Rudkjöbing, of Yerkes and McDonald Observatories, is that the small, red stars seem actually to be increasing in mass by the accretion of matter falling into them from the dust clouds in which they are imbedded. Dr. Struve characterized as "premature" any conclusion that these peculiar emission-line stars are really in the process of formation, but he regards this as a useful working hypothesis in our studies of stellar formation and evolution.

Two years ago astronomers were thrilled by the announcement from Mount Wilson Observatory that Dr. A. H. Joy had observed some 40 stars with strong emission lines in their spectra which were located in the vicinity of the great dust clouds in the constellation of Taurus. Dr. Joy suggested that the bright radiations of hydrogen, calcium, and other gases might be connected with the presence of diffuse matter in the vicinity of these stars.

In order to extend this study, the Yerkes astronomers have used the 82-inch McDonald reflector to obtain spectra of stars in the enormous opaque mass of cosmic dust which is located in the constellations Ophiuchus and Scorpius, about halfway between the bright stars Rho Ophiuchi and Sigma Scorpii. The stars in this region are mostly faint, and there are very few of them, because the dark cloud, at a distance of about 325 light-years from us, practically obliterates the light of the stars behind.

The bright *B* and *A* stars in the cloud were found to be in no way abnormal in their spectra, indicating that they did not "associate" with the nebulosity. Among the faint stars, a nest of emission-line objects was found. Five such peculiar stars were found close together, being located in one of the densest regions of the dark cloud. One of these stars was also variable in brightness, indicating its definite association with the nebulosity, and further clinching the similarity of these stars to the bright-line stars in Taurus.

All of the five stars have underlying spectra of dwarf *K* or early *M* type. In one or two the absorption features appear to be reduced in intensity by what looks like a general film of continuous emission. In this respect these stars also seem to resemble Joy's stars in Taurus. The brighter of the stars investigated, which range in apparent photographic magnitude from 12.5 to 15, are not appreciably obscured by the cloud, while the faintest may experience a photographic absorption of several magnitudes.

Irregular Variable RW Aurigae

IN 1944, at the Lick Observatory, an extensive investigation was begun of the star RW Aurigae, chosen as a rather extreme example of the T Tauri class of variable stars. This star varies between visual magnitudes 10.2 and 12.0 rapidly and erratically, and large changes in light may take place in a few hours. It lies on the edge of a small dark nebula which seems to be an outlying patch of the Taurus-Auriga dark clouds. Two types of observations were made: spectrophotometric, for the determination of energy distribution and emission-line intensities as the star varied in light; and spectroscopic, for the study of the displacements and structure of the emission lines which are characteristic of the T Tauri stars.

In reporting on this work, which was carried on with the 2-prism quartz slitless spectrograph of the Crossley reflector, Dr. George H. Herbig gave a semi-quantitative interpretation of some of the effects observed in RW Aurigae on the basis of the interaction of a main-

sequence star with a dark nebula. Metallic particles with radii smaller than about 1/100,000 centimeter will be rejected by the radiation pressure of a dwarf *G* star while larger ones will be drawn in by gravitation. Evaporation takes place from the surface of the larger particles falling in toward the star, and it is quite possible for a particle, initially above the critical size at which radiation pressure and gravitation affect it equally, to be "boiled down" below the critical radius and then rejected by radiation pressure. In general, the evaporated material will fall into a star of this spectral type so that a collapsing extended atmosphere will result. A number of the variable spectral features of RW Aurigae appear as a direct consequence of such a process, but with the details requiring further study.

A general survey of variable stars in diffuse nebulosity was also made, including such objects as 10 of the faint irregular variables in the Orion nebula, and two variables in Messier 8, in Sagittarius. All of these seem to be main-sequence stars with no sign of the emission features of the T Tauri stars. Apparently, when irregular variables are associated with diffuse nebulae excited by early-type high-luminosity stars (types *B* and *A*), those variables show no T Tauri emission lines. The critical radius of 1/100,000 centimeter for a dwarf *G* star increases for more luminous stars; for example, it is about 1/1,000 centimeter for a *B* star. As the metallic particles are themselves thought to range principally about the 1/100,000-centimeter size, the number of particles available for collection by a star drops off rapidly with increasing stellar luminosity. The *B* stars, therefore, "clear the air" around them of all but the largest particles, thereby preventing associated variables from being affected by the material which causes the T Tauri emission characteristics.

But when the nebula is a dark one, or is illuminated by a star of later spectral type, or when the variable in question lies in the nebula well outside the region illuminated by the bright star, T Tauri features generally are present. The new data confirms the fact, initially noted by Joy, that main-sequence stars of types *F*, *G*, and later seem to be most susceptible to emission characteristics when in contact with nebulosity.

Magnitudes and Colors in Nearby Clusters

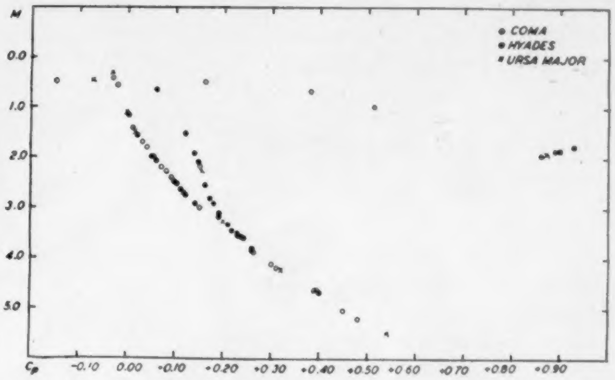
EVIDENCE that the all-important relation between the intrinsic brightness of a star and its temperature characteristics may be more precise than had previously been supposed was described by Olin J. Eggen, of Washburn Observatory. Photoelectric magnitudes and colors of stars in the Hyades and Coma Berenices clusters have been determined. Only some 50 stars of the 150-odd assigned to the Hyades cluster were observed, for it was a poor observing season at Madison, Wis. All stars brighter than photographic magnitude 10 in the Coma cluster were also observed.

Since the distance of the Coma cluster is large in comparison with its extent, any dispersion in a color-magnitude array must be due to errors in the observations and/or to a real dispersion in luminosity for a given color. Previous color-magnitude and spectrum-magnitude plots for this and other clusters have shown considerable dispersion, but Mr. Eggen's results, included in the accompanying graph, show no detectable dispersion in the main sequence.

The observed color-apparent-magnitude array for the Hyades members did contain a dispersion of as much as 0.5 magnitude for a given color. But as the Hyades cluster is only some 40 parsecs distant, this dispersion is to be expected from the differential in the distances of the members. When the individual magnitudes were reduced to absolute values by means of individual distances obtained from well-determined proper motion and radial velocity data, the dispersion disappeared, and these stars fell into their proper places along with those of the Coma cluster.

Another feature of considerable significance resulting from Mr. Eggen's data is the splitting of the main sequence at about absolute photographic magnitude +3.0. The previously undetected branch rises somewhat more steeply than does the main sequence, and it consists of giant *A* stars, the most luminous in the Hyades being Theta² Tauri. The lower portion of this new (upper) branch contains the metallic-line stars. Note that there is one star in the Coma cluster which falls on this vertical branch and this also is a metallic-line star.

A few of the members of the Ursa Major moving cluster have also been observed by Mr. Eggen, whose method is to alternate red and blue filters in front of the photomultiplier tube, to get each star's color index. A metallic-line star, 41 Virginis, also falls on the upper branch among other stars of this type.



International color index (abscissae) against international photographic absolute magnitude, for stars in three clusters. The isolated few stars at the right, 2nd magnitude, are yellow giants, mostly in the Hyades. From observations at Washburn Observatory.

The inference from this work is that the photoelectric observations give us color-magnitude measures of such great accuracy that we may attribute much of the scatter in earlier brightness-temperature diagrams to errors in the measurements of the required quantities rather than to any complex nature of the stars themselves. Further observations of cluster stars may be expected to strengthen these results, and to make possible the determination of the absolute brightness of a star to the nearest 0.05 magnitude from its color index alone.

EARLY CHAPTERS IN THE HISTORY OF STELLAR EVOLUTION

(Continued from page 273)

nection with our first hypothesis. Actually, it is convenient to work backward and calculate the size of the region from the known angular momentum of the planets. The calculation gives a result of exactly the right order.

It may thus be supposed that the material out of which the solar system was formed was derived from two different sources. The bulk of the material came from a filament and was of large mass and of very small angular momentum. The whole of this material condensed to form the sun. The remainder of the material was captured from interstellar space, and was of comparatively small mass but of large angular momentum. Some of this material was added to the sun and gave the sun its rotation, which is in the same sense as the orbital revolution of the planets. The remainder of the material went to form the planets and their satellites.

It will thus be seen that the filament theory does more than provide a plausible and consistent explanation of the evolution of the stars. It removes an outstanding difficulty in the theory of the solar system, which need no longer be regarded as the unique product of a rare and improbable coincidence. If the filament hypothesis is acceptable, the solar system can take its place as the natural product of a normal process of astronomical evolution.

BOOKS AND THE SKY

THE CONTROL OF ATOMIC ENERGY

James R. Newman and **Byron S. Miller.** Whittlesey House, New York, 1948. 434 pages. $5.00.

THIS BOOK is a study of the social, economic, and political implications of the atomic energy act of 1946. Both authors are well equipped to discuss the act, as they assisted Senator Brien McMahon in drafting his bill. Mr. Newman was head of the science division of the Office of War Mobilization and Reconversion and White House adviser on science and atomic energy legislation.

The scope of the book can best be described by a discussion of material in the order in which it is presented. The introduction calls sharp attention to the fact that "the Atomic Energy Act is a radical piece of legislation. . . . The Act creates a government monopoly of the sources of atomic energy and buttresses this position with a variety of broad governmental powers and prohibitions on private activity. The field of atomic energy is made an island of socialism in the midst of a free enterprise economy."

The authors discuss the organization and structure of the commission; the control, production, and ownership of fissionable material; industrial and commercial uses; and the laws concerning patents and inventions. The government's policies of research and control of information are considered in detail, while the military applications of atomic energy constitute one of the shortest sections.

About one third of the book is appendices. These include the atomic energy act, the espionage act, the British atomic energy act, and some of the regulations on control of source materials issued by the United States Atomic Energy Commission.

In the opinion of this reviewer, the book is too specifically a study of this single Act of Congress, all-important as it is, to be of general interest to the casual reader. On the other hand, it should prove useful and informative to anyone who is seriously interested in the problems of atomic energy or whose occupation or special interests fall under the jurisdiction of the Atomic Energy Commission.

SANBORN C. BROWN
Massachusetts Institute of Technology

ELEMENTARY NUCLEAR THEORY

H. A. Bethe. John Wiley and Sons, Inc., New York, 1947. 147 pages. $2.50.

THIS BOOK is based upon a series of lectures given by Dr. H. A. Bethe to a group of scientists and engineers at the General Electric Research Laboratories as an introduction to the subject matter of a project to be carried out for the Atomic Energy Commission. In **Elementary Nuclear Physics** Dr. Bethe analyzes the primary problems of nuclear research for those readers who have a fairly extensive background in modern physics, but are

NEW BOOKS RECEIVED

LUNAR CATASTROPHIC HISTORY, *J. E. Spurr,* 1948, *Rumford Press.* 253 pages. $5.00.

Written as Part III of the author's study of *Geology Applied to Selenology,* the present volume presents further work on the subject, bearing especially on some of the problems developed in the preceding book, *Features of the Moon.*

PRACTICAL ASTRONOMY, *Jason John Nassau,* 1948, *McGraw-Hill.* Second edition, 311 pages. $5.00.

This edition is about 50 per cent larger than the book first published in 1931. Part I contains material suitable for a first course in practical astronomy, and Part II the advanced discussions necessary for field work in geodetic astronomy.

WEATHER ELEMENTS, *Thomas A. Blair,* 1948, *Prentice-Hall.* Third edition, 373 pages. $5.65.

A third edition brings up to date this well-known book on meteorology, designed to serve as an introductory text or to provide background material for airplane pilots and students in allied sciences.

PRACTICAL ASTRONOMY, *Hosmer* and *Robbins,* 1948, *Wiley.* Fourth edition, 355 pages. $4.50.

This standard text by the late George L. Hosmer has been revised and rewritten by James M. Robbins, of the Newark College of Engineering. Its first part is designed for both the navigator and the surveyor, the second part chiefly to fill the needs of the surveyor.

ASTRONOMIE, *Rudaux* and *Vaucouleurs,* 1948, *Librairie Larousse.* 486 pages. Price not supplied.

With 866 photographs and 12 colored plates, its text in French, this volume treats popular astronomy in the manner of *Splendour of the Heavens,* but it is quite up to the minute in its presentation of the latest researches and facts.

not specialists in nuclear physics. In his exposition of the rapidly growing field of nuclear theory, Dr. Bethe has made use of what might be termed "the more elementary aspects" of advanced mathematics and of quantum mechanics. For one having a knowledge of these general fields, this is an elementary introduction to nuclear theory. For the average lay reader, however, the title of the book is apt to be misleading.

There are three main sections: "Descriptive Theory of Light Nuclei," "Quantitative Theory of Nuclear Forces," and "Topics Not Related to Nuclear Forces." In the first of these is given a brief but, for the purpose, adequate account of the basic, well-established facts about atomic nuclei. The second, and by far the largest, section of the book deals with what Dr. Bethe terms the "central problem" of nuclear physics — the problem of nuclear forces. Here he describes the physical properties of the proton, neutron, and deuteron, and discusses in elementary terms the theory and observation of the scattering of neutrons by protons both free and bound in molecules, the interaction of deuterons with radiation, the scattering of protons by protons, the problems of non-central nuclear forces and the saturation of nuclear forces, and, finally, he sketches the status of the meson theory of nuclear forces. The third section deals briefly but well with beta disintegration and the theory of the compound nucleus.

The book concludes (aside from an index) with an appendix that gives all known nuclear masses, abundances, and spins, and, for the radioactive nuclei, radiations emitted.

Throughout the entire volume Dr. Bethe has treated his subject from the empirical point of view; purely theoretical considerations have been omitted. In following this course the author has achieved a remarkably clear and readable presentation of the basic material necessary to give the non-specialist a good introduction to the field of nuclear physics. To the members of the fairly large group of readers for which it is intended, **Elementary Nuclear Theory** is much to be recommended. In reading the book and in referring it to others, the only slight disappointment one might feel is that Dr. Bethe did not make it somewhat longer and more inclusive.

HAROLD F. WEAVER
Lick Observatory

IN FOCUS

(Continued from page 266)

observations made at the f/16 Cassegrainian focus. It also provides a support for the coude diagonal mirror measuring 36 x 53 inches. The ring around this tube just above the mirror's surface provides a resting place or stop for the leaves that cover the mirror when it is not in use. The cover is designed to act as a diaphragm and its circular opening will determine the area of the mirror to be exposed on nights of bad seeing. Details of the mechanism that controls these leaves are shown at the lower right and just to the left of the cutaway portion of the base ring.

Five of the 36 adjusting cylinders that are in the special wells in the back of the mirror are shown, two in a cutaway that reveals their construction. The cylinders are over 11 inches in diameter, varying in height from 16 inches near the center to a little less than 20 inches near the periphery, and transmit their burden over the lever system underneath where delicate adjustments can be made. Note that the cylinders touch only the walls and bottoms of the openings, never the tops of the wells. This prevents distorting the relatively thin solid portion of the mirror and ruining the definition of the finely figured surface.

GLEANINGS FOR A. T. M.s

THE COMPOUND REFLECTING TELESCOPE — V

By Allyn J. Thompson

Optical Design. Matters of first consideration are the diameter of the primary mirror and the equivalent focal length of the telescope. The former will be decided by the individual according to his needs and capabilities. The latter will depend equally on the focal length of the primary and on the amplifying ratio, which may be almost anything desired, but it should be borne in mind that the size of the field of view varies inversely as the focal length, and any increase in magnification can be gained only at the expense of the available field.

Focal length and amplification are likewise matters of individual preference, but the primary mirror is most practically made f/3 to f/5, amplification bringing the equivalent focal ratio up to between about f/12 and f/30. Practical design will hardly allow of a lower amplifying ratio than 3, and 10 is probably a useful upper limit. To go below f/12 with the equivalent focal ratio seems a needless sacrifice of much of the potential power of the compound reflector, aside from the fact that except in the large diameters it then invades the realm of the simpler Newtonian. Because of the diminishing field of view it is generally impractical to go beyond about f/30.

We shall now proceed to plan a compound reflector employing a convex secondary mirror (Fig. 19). In contemplating construction of this type of telescope, a number of questions at once arise, each seeming to have precedence of some sort, and a variety of methods of approach present themselves. However, let us suppose as an introductory argument that while large images of the planets are desirable in our model, it is also wished that the whole of the moon's disk be available for study at a single view. As the moon's greatest angular diameter when in best position for observing may be about 33 minutes of arc, an angular field of view no smaller than this must be made available to a low-power eyepiece. A standard low-power astronomical eyepiece can accommodate a linear field about one inch in diameter. The tangent of 33 minutes (taken from a table of tangents) is 0.0096; therefore the focal length needed to procure an image of the moon one inch in diameter is 1/0.0096, or 104 inches. As the equivalent focal length divided by the mirror diameter equals the primary focal ratio times the amplification, it is evident that by appropriate choice of focal and amplifying ratios a mirror 10 inches in diameter might be used. But in that case, and for an 8-inch diameter also, the low-power eyepiece will be unable to make use of the mirror's resolving power. The objection is not a serious one, however, but from considerations of compactness and economy, we choose a 6-inch diameter mirror. And by selecting an equivalent focal length of 102 inches, instead of 104, we obtain the even figure f/17 for the equivalent focal ratio. The angular field of view is thereby increased slightly, to about 34 minutes of arc.

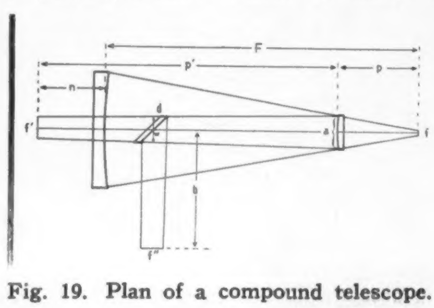


Fig. 19. Plan of a compound telescope.

The location of the secondary focal plane must now be decided. It can be made to fall either in back of the mirror as in Fig. 2, or to the side of the tube as at f", Fig. 19. In the first instance a star diagonal is a practical necessity from the standpoint of observing comfort; this requires that the focal plane lie at least eight inches (for a 6-inch mirror) back of the vertex of the primary. Less travel is required of the secondary reflection in

the second instance, hence a lower amplifying ratio can be used, and there are fewer construction difficulties to be met. A third reflection is called for in either case, but as the advantages of the second method are substantial, that is the one used here.

There are an infinite number of permissible combinations of focal and amplifying ratios that will yield the equivalent focal ratio f/17, and a choice should be judiciously made. It is advisable for the amateur to use as large a focal ratio as possible for his primary mirror, but then to meet the foregoing conditions regarding field of view, the amplifying ratio would have to be correspondingly low. In that case the distance **p′** (Fig. 19) would be too short, unless the secondary obstruction were to be considerably larger than desirable.

A focal ratio of f/3.4 and an amplifying ratio of 5 are found well suited to our requirements. The focal length of the primary mirror is thus to be 20.4 inches.

A scale drawing of the telescope, similar to Fig. 19 and preferably of actual size, is of the utmost importance in verifying calculations, and should be made at this stage. The linear width of the approximately 34-minute field at the primary focus **f** is equal to 20.4 times the tangent of 34 minutes, or 0.2″. The amplified field at the secondary focus is, of course, five times this, or 1″ in width. The locations of the secondary mirror and the diagonal, **d**, are next to be ascertained.

To avoid injurious diffraction in the image, the diameter of the central obstruction should not exceed about ¼ that of the primary mirror. This establishes a practical limitation to the distance (**p**) the secondary can be placed inside the focus. In evolving the formula below, it was assumed that the secondary will be enclosed in a cell, the circumference of which constitutes the boundaries of the obstruction. The amount by which the retaining cell exceeds the clear aperture of the secondary is the term **x** in the formula,

$$\text{Maximum } \mathbf{p} = \frac{\mathbf{F}\,(\mathbf{A}/4 - \mathbf{x} - \mathbf{f})}{\mathbf{A} - \mathbf{f}}, \quad (4)$$

where **F** is the focal length of the primary mirror, **A** its aperture, **f** the linear width of the primary focal plane, and **x** has the meaning described above. If, in our model telescope, **x** amounts to 0.062″, the limiting distance **p** will be found to be 4.35″. But at this distance the secondary focal plane will fall a little too far out for our purposes. It is an easy matter to move the secondary closer to **f**, at the same time effecting a beneficial reduction in its size. A compatible distance for **p** is found to be 4″, and **p′** therefore is 20″, as the amplification is five times.

The clear aperture of the secondary mirror at the selected distance **p** is

$$\mathbf{a} = \frac{\mathbf{p}\,(\mathbf{A} - \mathbf{f})}{\mathbf{F}} + \mathbf{f}. \quad (5)$$

For our telescope, the aperture of the secondary mirror will be 1.337″, the retaining cell increasing the obstructing diameter to about 1.4″, satisfactorily less than the recommended limit.

The secondary's radius of curvature can be calculated from the formula,

$$\mathbf{r} = \frac{2\mathbf{p}'\,\mathbf{p}}{\mathbf{p}' - \mathbf{p}}, \quad (6)$$

from which the radius of our secondary is found to be 10″.

The diagonal (or prism) **d** cannot be placed closer to the mirror than its supports will permit; on the other hand, if it is removed from the primary by more than a very few inches (in our case) it will unduly obstruct field rays being reflected from the mirror's central zones. At any rate, assuming that the telescope will be enclosed in a 6½″ or 7″ tube, about 6″ will be required for **b**, the deflected portion of **p′**. This fixes the center of the

diagonal about 2.4" from the primary mirror, in which position it makes a grazing but harmless acquaintance with the above-mentioned reflections. (It can be seen that if the focal length of the mirror were greater, a difficulty would be encountered here.) The minor axis or width of the diagonal in the above location is

$$\mathbf{w} = \frac{\mathbf{b}\,(\mathbf{a} - \mathbf{f}'')}{\mathbf{p}'} + \mathbf{f}'', \qquad (7)$$

where $\mathbf{f}''$ is the linear width of the secondary focal plane. The major axis or length of the diagonal is equal to $\mathbf{w}$ times 1.4. This gives our telescope a diagonal measuring 1.1" x 1.55", or a right-angle prism with 1.1" square faces. The size of the diagonal should be pretty well confined to the computed dimensions, and it is best made elliptical in shape. Although little interference will result from a rectangular diagonal, its corners should be ground off if its major dimension exceeds the diameter of the secondary obstruction, otherwise they will introduce additional diffraction in the image.

While perforation of the primary mirror is not called for in the design of Fig. 19, a central hole an inch or so in diameter will be found to be a convenience in testing with the optical flat. This hole might be used to hold a rod supporting the diagonal, and in any event the adjustments of the diagonal may be so designed that they can be manipulated from the back of the mirror. The alternative is to have them accessible through a hole in the side of the tube opposite the eyepiece opening.

Where it is planned to have the focal plane fall in back of the mirror, the perforation should be large enough to permit the unobstructed passage of all the rays illuminating the field of view. It should not, however, be larger than the diameter of the secondary mirror cell minus the linear width of the primary focal plane $\mathbf{f}$. The minimum diameter of the hole, or the width of the useful cone of rays passing through the mirror, is

$$\mathbf{h} = \frac{\mathbf{n}\,(\mathbf{a} - \mathbf{f}')}{\mathbf{p}'} + \mathbf{f}', \qquad (8)$$

where $\mathbf{f}'$ is the linear width of the secondary focal plane and $\mathbf{n}$ its distance from the vertex of the primary mirror.

So that none of the oblique rays from the edges of the field of view will be cut off at the tube entrance, the minimum internal diameter of the tube at that end should not be less than the diameter of the mirror plus the linear width of the primary focal plane $\mathbf{f}$.

In addition to the recommended full-scale drawing, all of the data essential for incidental computation and for construction of the telescope should be compiled and listed as follows:

Diameter of primary mirror	6"
Focal length of primary mirror	20.4"
Focal ratio of primary mirror	f/3.4
Amplifying ratio	5
E.F.L.	102"
E.F.R.	f/17
Linear field f	0.2"
Linear field f'	1"
Angular field f or f'	34'
Length of p	4"
Length of p'	20"

Diameter of secondary (clear)	1.337"
Radius of secondary	10"
F.L. (negative) of secondary	5"
Distance, secondary from primary	16.4"
Distance, diagonal from primary	2.4"
Distance, diagonal to secondary	14"
Dimensions of diagonal	1.1" x 1.55"
Length of *b*	6"
Least internal tube diameter	6.2"

Shop Procedures. The technique of mirror making is described in such books as **Amateur Telescope Making** and **Making Your Own Telescope.** In order to facilitate the polishing and figuring operations, use of the molded lap, and either Barnesite or cerium oxide as the polishing agent, is strongly advised. By these means the author has completely polished three 6-inch f/3.5 mirrors in ½ hour each.

Small departures of focal length of either primary or secondary mirror from the previously established figures, such as are apt to result with the average amateur, will have an insignificant effect on aberrations, but to avoid the possibility of having to revise existing plans, only a very small difference should be tolerated. In the grinding stages, the wetted surface of the concave mirror or tool of low focal ratio will reflect a rather sharp image of a luminous aperture, making possible quite exact measurement well in advance of polishing; hence radii can be kept within 0.1" of the predetermined lengths. In the case of the primary mirror, due allowance should be made for the shortening of its focal length during figuring. If, for example, our 6-inch f/3.4 mirror were to be given the ellipsoidal figure needed for the Dall-Kirkham telescope, the radius of its center zone would be reduced in the figuring by 78.3 per cent of $\mathbf{r^2/2R}$, or about 1/12 of an inch. Therefore, a radius of 40.9 inches prior to figuring should be aimed at. Any shortening of the radius of low-ratio mirrors that may otherwise take place during polishing is negligible.

(To be continued)

LETTERS

(Continued from page 274)

27 years. To make a gear with 401 teeth would present no difficulty today.

Other ratios, together with their respective periods to gain or lose one second, are $105{,}844/105{,}555 = 4\cdot 47\cdot 563/15\cdot 31\cdot 227 = 8\cdot 47\cdot 563/30\cdot 31\cdot 227$, which loses one second in 225 years; $178{,}360/177{,}873 = 2^3\cdot 5\cdot 7^3\cdot 13/3\cdot 211\cdot 281 = 40\cdot 49\cdot 91/3\cdot 211\cdot 281$, loses, 41 years; $220{,}844/220{,}241 = 31\cdot 52\cdot 137/7\cdot 73\cdot 431$, gains, 58 years. Then there are $446{,}083/444{,}865 = 11\cdot 107\cdot 379/5\cdot 193\cdot 461$, loses, 916 years; $456{,}704/455{,}457 = 64\cdot 64\cdot 223/6\cdot 157\cdot 967$, gains, 292 years; $467{,}325/466{,}049 = 67\cdot 75\cdot 93/23\cdot 23\cdot 881$, gains, 129 years; $620{,}048/618{,}355 = 44\cdot 52\cdot 271/23\cdot 95\cdot 283$, gains, 192 years.

The rate of gain or loss for these ratios was computed for the year 1950, but will be substantially the same for hundreds of years to come, as the length of the tropical year changes by only half a second in a century.

JOHN L. BRANDNER
6629 N. Washtenaw Ave.
Chicago 45, Ill.

diagonal about 2.4" from the primary mirror, in which position it makes a grazing but harmless acquaintance with the above-mentioned reflections. (It can be seen that if the focal length of the mirror were greater, a difficulty would be encountered here.) The minor axis or width of the diagonal in the above location is

$$w = \frac{b\,(a - f'')}{p'} + f'', \qquad (7)$$

where **f"** is the linear width of the secondary focal plane. The major axis or length of the diagonal is equal to **w** times 1.4. This gives our telescope a diagonal measuring 1.1" x 1.55", or a right-angle prism with 1.1" square faces. The size of the diagonal should be pretty well confined to the computed dimensions, and it is best made elliptical in shape. Although little interference will result from a rectangular diagonal, its corners should be ground off if its major dimension exceeds the diameter of the secondary obstruction, otherwise they will introduce additional diffraction in the image.

While perforation of the primary mirror is not called for in the design of Fig. 19, a central hole an inch or so in diameter will be found to be a convenience in testing with the optical flat. This hole might be used to hold a rod supporting the diagonal, and in any event the adjustments of the diagonal may be so designed that they can be manipulated from the back of the mirror. The alternative is to have them accessible through a hole in the side of the tube opposite the eyepiece opening.

Where it is planned to have the focal plane fall in back of the mirror, the perforation should be large enough to permit the unobstructed passage of all the rays illuminating the field of view. It should not, however, be larger than the diameter of the secondary mirror cell minus the linear width of the primary focal plane **f**. The minimum diameter of the hole, or the width of the useful cone of rays passing through the mirror, is

$$h = \frac{n\,(a - f')}{p'} + f', \qquad (8)$$

where **f'** is the linear width of the secondary focal plane and **n** its distance from the vertex of the primary mirror.

So that none of the oblique rays from the edges of the field of view will be cut off at the tube entrance, the minimum internal diameter of the tube at that end should not be less than the diameter of the mirror plus the linear width of the primary focal plane **f**.

In addition to the recommended full-scale drawing, all of the data essential for incidental computation and for construction of the telescope should be compiled and listed as follows:

Diameter of primary mirror	6"
Focal length of primary mirror	20.4"
Focal ratio of primary mirror	f/3.4
Amplifying ratio	5
E.F.L.	102"
E.F.R.	f/17
Linear field *f*	0.2"
Linear field *f'*	1"
Angular field *f* or *f'*	34'
Length of *p*	4"
Length of *p'*	20"

Diameter of secondary (clear)	1.337"
Radius of secondary	10"
F.L. (negative) of secondary	5"
Distance, secondary from primary	16.4"
Distance, diagonal from primary	2.4"
Distance, diagonal to secondary	14"
Dimensions of diagonal	1.1" x 1.55"
Length of *b*	6"
Least internal tube diameter	6.2"

Shop Procedures. The technique of mirror making is described in such books as **Amateur Telescope Making** and **Making Your Own Telescope.** In order to facilitate the polishing and figuring operations, use of the molded lap, and either Barnesite or cerium oxide as the polishing agent, is strongly advised. By these means the author has completely polished three 6-inch f/3.5 mirrors in ½ hour each.

Small departures of focal length of either primary or secondary mirror from the previously established figures, such as are apt to result with the average amateur, will have an insignificant effect on aberrations, but to avoid the possibility of having to revise existing plans, only a very small difference should be tolerated. In the grinding stages, the wetted surface of the concave mirror or tool of low focal ratio will reflect a rather sharp image of a luminous aperture, making possible quite exact measurement well in advance of polishing; hence radii can be kept within 0.1" of the predetermined lengths. In the case of the primary mirror, due allowance should be made for the shortening of its focal length during figuring. If, for example, our 6-inch f/3.4 mirror were to be given the ellipsoidal figure needed for the Dall-Kirkham telescope, the radius of its center zone would be reduced in the figuring by 78.3 per cent of $r^2/2\mathbf{R}$, or about 1/12 of an inch. Therefore, a radius of 40.9 inches prior to figuring should be aimed at. Any shortening of the radius of low-ratio mirrors that may otherwise take place during polishing is negligible.

(To be continued)

LETTERS

(Continued from page 274)

27 years. To make a gear with 401 teeth would present no difficulty today.

Other ratios, together with their respective periods to gain or lose one second, are $105{,}844/105{,}555 = 4 \cdot 47 \cdot 563/15 \cdot 31 \cdot 227 = 8 \cdot 47 \cdot 563/30 \cdot 31 \cdot 227$, which loses one second in 225 years; $178{,}360/177{,}873 = 2^3 \cdot 5 \cdot 7^3 \cdot 13/3 \cdot 211 \cdot 281 = 40 \cdot 49 \cdot 91/3 \cdot 211 \cdot 281$, loses, 41 years; $220{,}844/220{,}241 = 31 \cdot 5^2 \cdot 137/7 \cdot 73 \cdot 431$, gains, 58 years. Then there are $446{,}083/444{,}865 = 11 \cdot 107 \cdot 379/5 \cdot 193 \cdot 461$, loses, 916 years; $456{,}704 / 455{,}457 = 64 \cdot 64 \cdot 223 / 6 \cdot 157 \cdot 967$, gains, 292 years; $467{,}325/466{,}049 = 67 \cdot 75 \cdot 93/23 \cdot 23 \cdot 881$, gains, 129 years; $620{,}048 / 618{,}355 = 44 \cdot 52 \cdot 271 / 23 \cdot 95 \cdot 283$, gains, 192 years.

The rate of gain or loss for these ratios was computed for the year 1950, but will be substantially the same for hundreds of years to come, as the length of the tropical year changes by only half a second in a century.

JOHN L. BRANDNER
6629 N. Washtenaw Ave.
Chicago 45, Ill.

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

OCCULTATION PREDICTIONS

Mars will be occulted on Labor Day, September 6th, but it will be a daylight affair requiring careful search for the three-day-old moon, and then continued telescopic observation to watch the planet, of magnitude only 1.5, as it is hidden by the lunar disk. Predicted times are given for all stations in the United States and Canada. On the West Coast the moon will be east of the meridian at the time of immersion. At the Texas standard station the occultation lasts an hour and 25 minutes. Several minutes of this period are accounted for by Mars' own motion eastward while it is hidden by the moon, its daily change in longitude at this time being about 31'.5.

The planet's distance from the earth on September 6th is 1.99 astronomical units, and its apparent diameter is then only 2".35, much less than the 3".9 which separates the components of the double, Castor, and about equal to the separation of the closer pair in Epsilon Lyrae. Considering the brightness of the sky, Mars itself will be hard to find before eclipse — a good telescope with relatively low power is recommended. Careful prediction of the position angle for one's own station may be necessary if emersion is to be observed as soon as it occurs.

September 6-7 **MARS** 1.5, 14:00 −12-33, 3, Im: **A** 22:16.9 −2.6 0.0 56; **B** 22:15.0 ... ... 49; **C** 22:06.6 −2.5 −0.4 72; **D** 21:59.0 −2.6 −0.2 66; **E** 21:31.2 −2.3 −0.5 96; **F** 21:24.4 −1.8 −1.3 129; **G** 20:50.0 −1.2 +0.3 113; **H** 20:51.7 −0.4 −1.5 161; **I** 20:40.7 −0.8 +0.1 129. Em: **A** 22:49.4 −0.4 −3.3 6; **B** 22:39.2 ... ... 12; **C** 22:57.3 −0.8 −2.8 352; **D** 22:42.6 −0.5 −2.7 358; **E** 22:42.2 −1.1 −2.0 336; **F** 22:50.8 −1.9 −1.7 309; **G** 22:02.6 −1.0 −0.7 318; **H** 21:58.8 −2.3 +0.2 278; **I** 21:53.2 −1.2 −0.1 302.

13-14 **40 B Capricorni** 6.2, 20:29.8 −25-07.2, 11, Im: **A** 0:46.8 −2.0 +0.9 69; **B** 0:47.5 −1.8 +0.9 65; **C** 0:33.7 −2.1 +1.1 71; **D** 0:34.8 −1.8 +1.2 65; **E** 0:09.1 −1.6 +1.6 71; **F** 23:46.0 −1.2 +0.9 95.

14-15 **35 Capricorni** 6.0, 21:24.3 −21-25.3, 12, Im: **A** 4:20.7 −3.6 −2.7 121; **B** 4:11.5 −2.5 −1.5 107; **C** 4:12.9 −3.9 −2.4 119; **D** 3:59.0 −2.5 −0.8 100; **E** 3:31.2 −2.4 +0.3 87; **F** 3:08.4 −3.0 +0.3 96; **G** 3:00.5 −1.3 +1.5 60; **H** 2:28.1 −1.5 +1.5 77.

22-23 **14 H¹ Tauri** 6.4, 3:36.0 +20-44.9, 20, Em: **G** 10:56.8 −1.3 +1.3 234; **H** 10:51.1 −0.5 +3.4 197; **I** 10:43.1 −1.3 +1.5 241.

27-28 **28 Cancri** 6.1, 8:25.5 +24-19.1, 25, Em: **A** 7:23.2 −0.6 +0.3 304; **B** 7:22.9 −0.7 0.0 316; **C** 7:19.7 −0.4 −0.4 298; **D** 7:19.7 −0.5 0.0 318.

27-28 **Upsilon¹ Cancri** 5.7, 8:28.4 +24-15.5, 25, Em: **A** 8:36.9 −1.1 −0.1 310; **B** 8:34.6 −1.1 −0.6 323; **C** 8:32.4 −0.9 +0.2 301; **D** 8:29.7 −1.0 −0.5 322; **E** 8:21.0 −0.8 −0.6 324.

27-28 **Upsilon² Cancri** 6.4, 8:29.9 +24-15.8, 25, Em: **A** 9:12.0 −1.4 −1.2 325; **B** 9:05.0 −1.7 −3.0 344; **C** 9:08.8 −1.2 −0.5 314; **D** 9:00.6 −1.6 −2.4 341; **E** 8:50.3 −1.5 −2.1 340; **F** 8:52.0 −0.6 −0.2 307.

For selected occultations visible at standard stations in the United States and Canada under fairly favorable conditions, these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	E +91°.0, +40°.0
B +73°.6, +45°.6	F +98°.0, +30°.0
C +77°.1, +38°.9	G +114°.0, +50°.9
D +79°.4, +43°.7	H +120°.0, +36°.0
I +123°.1, +49°.5	

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

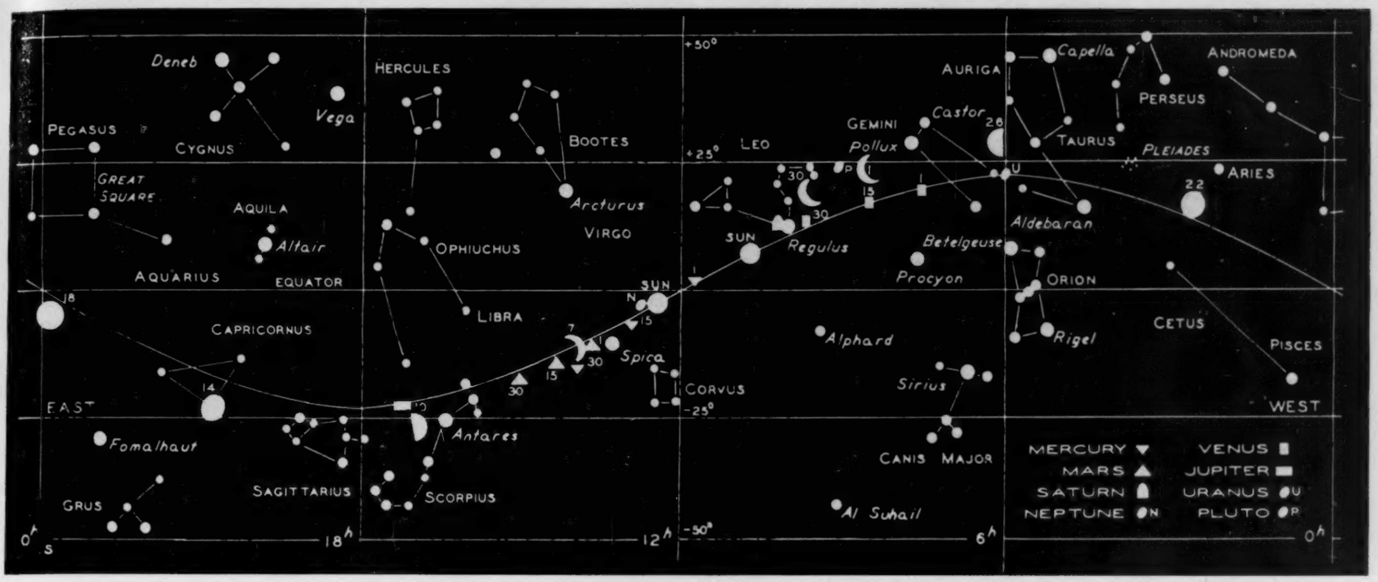
MOON NOTES

PHENOMENA associated with the moon are noteworthy this fall. The harvest moon in September and the hunter's in October rise less than 25 minutes later each succeeding four nights after full. And five days after the full phase in September, one may see the moon as early as two hours after sunset. Note also the early setting of the first-quarter moon, two hours before midnight in September and 1½ hours the next month. Conversely, last quarter may be seen two hours before midnight in these months. Next spring these conditions will be just reversed.

Perigee occurs on September 3rd, at 6:00 GCT, with the moon new the same day at 11:21. Apogee therefore occurs near full moon, so our satellite then appears about 25 per cent fainter than does a perigee full moon. This results from the fact that the distance from the earth to the moon at perigee is only about 8/9 that at apogee. The brightness varies inversely as the square of the distance.

The westward moving ascending node of the moon's orbit, the point where the moon crosses the ecliptic going northward, is now in western Aries, about 36 degrees from the vernal equinox, with which the node will coincide in 1951. Already this situation is resulting in a wide range in the moon's meridian altitude during the month. The change in 15 days is nearly 56 degrees in September, from −27° 45' on the 11th to +27° 51' on the 26th. At these times the moon is in Sagittarius and Gemini, respectively.

Favorable lunar librations will occur for both waxing and waning phases. From September 7th to 11th, the moon's west limb will be turned about seven degrees toward the earth, and we shall see Mare Crisium at its maximum distance from



the limb. This occurs during first quarter, so two weeks later, at last quarter, the libration is nearly as great in the opposite direction and Grimaldi will be noticeably far from the east limb. Similar librations will occur October 7-9 and October 22-23.

On several occasions, with the aid of field glasses, I have watched the crescent moon through first quarter to determine how long earthshine remains visible. Two to three days past first quarter the larger maria in the unlit portions of the moon's disk could be discerned. By the fourth night after first quarter, no earthshine could be detected.

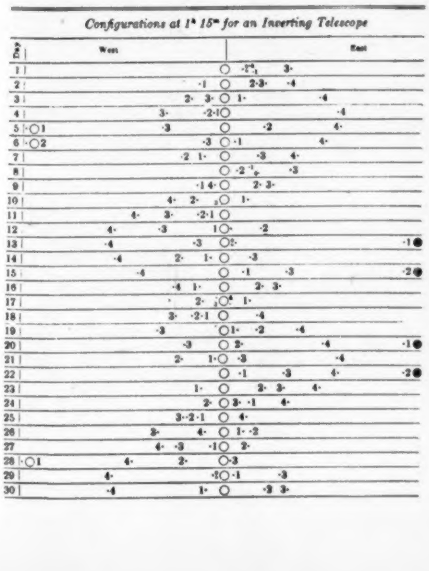
EDWARD ORAVEC

PHASES OF THE MOON

New moon	September 3,	11:21
First quarter	September 10,	7:05
Full moon	September 18,	9:43
Last quarter	September 26,	5:07
New moon	October 2,	19:42

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the American Ephemeris and Nautical Almanac.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Sun. On September 23rd at 3:22 GCT, which is in the evening hours across the United States on September 22nd, the sun crosses the celestial equator southward. Autumn commences in the Northern Hemisphere, spring in the Southern.

Mercury, an evening star, is poorly placed for observation all month. Although it reaches greatest eastern elongation on the 25th, the planet will be less than 8° above the horizon at sunset for observers in latitude 40° north, hence difficult to locate.

Venus reaches greatest western elongation on September 3rd, its magnitude −4.0. In early September, halfway up the morning sky at sunrise, it is midway between Pollux and Procyon; on the 30th it is about 6° west of Regulus.

Mars, considerably diminished in brightness, is approaching the sun in the evening sky. On the 1st it is 6° east of Spica, setting two hours after sunset. A daylight occultation of the planet will occur on September 6th, to be observed only with the aid of a telescope. Times predicted for this occultation may be found under Occultation Predictions elsewhere in this department. By September 30th, Mars will be in central Libra, still setting nearly two hours after the sun.

Jupiter, in Ophiuchus, is in eastern quadrature with the sun on September 13th. It is a conspicuous evening object, deep in the southern sky and setting before midnight.

Saturn emerges from the region of the sun into the morning sky in early September. It is close to Regulus, passing less than a degree north of that star on the 9th. By the 30th, Saturn will rise three hours before the sun.

Uranus is in Gemini, and may be observed from midnight until dawn. Its position on the 15th is at 6^h 2^m, +23° 38′.

Neptune is too close to the sun to be observed.

E. O.

VARIABLE STAR MAXIMA

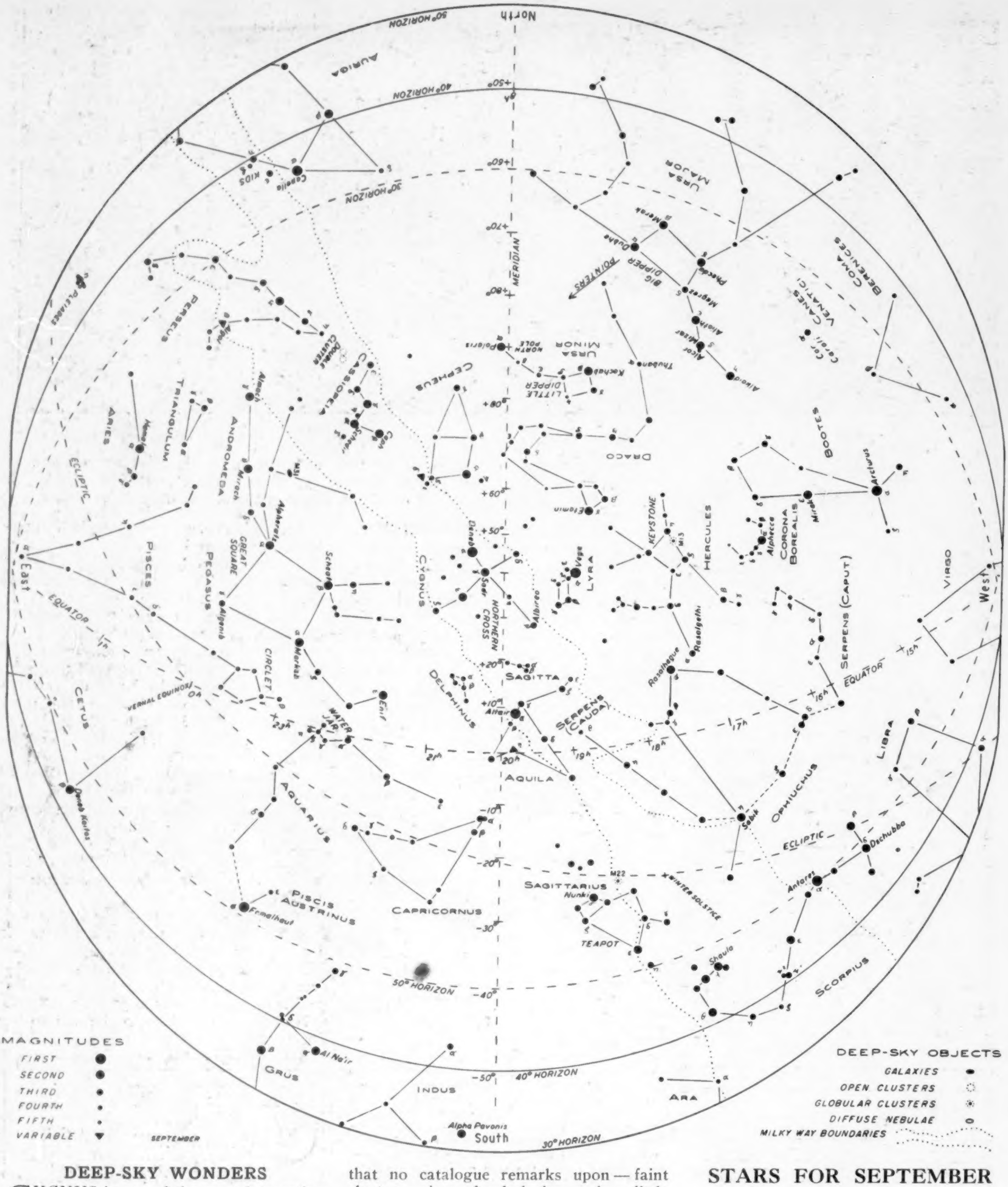
September 7, X Monocerotis, 7.6, 065**208**; 10, X Ophiuchi, 6.9, 183308; 17, RT Cygni, 7.4, 194048; 27, Omicron Ceti, 3.7, 021**403**.

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



DEEP-SKY WONDERS

CYGNUS is one of the most interesting of all the areas in the entire sky. The North America nebula near Deneb cannot be observed readily without photography, but the region is so rich that it is well worth sweeping with anything from binoculars to large telescopes.

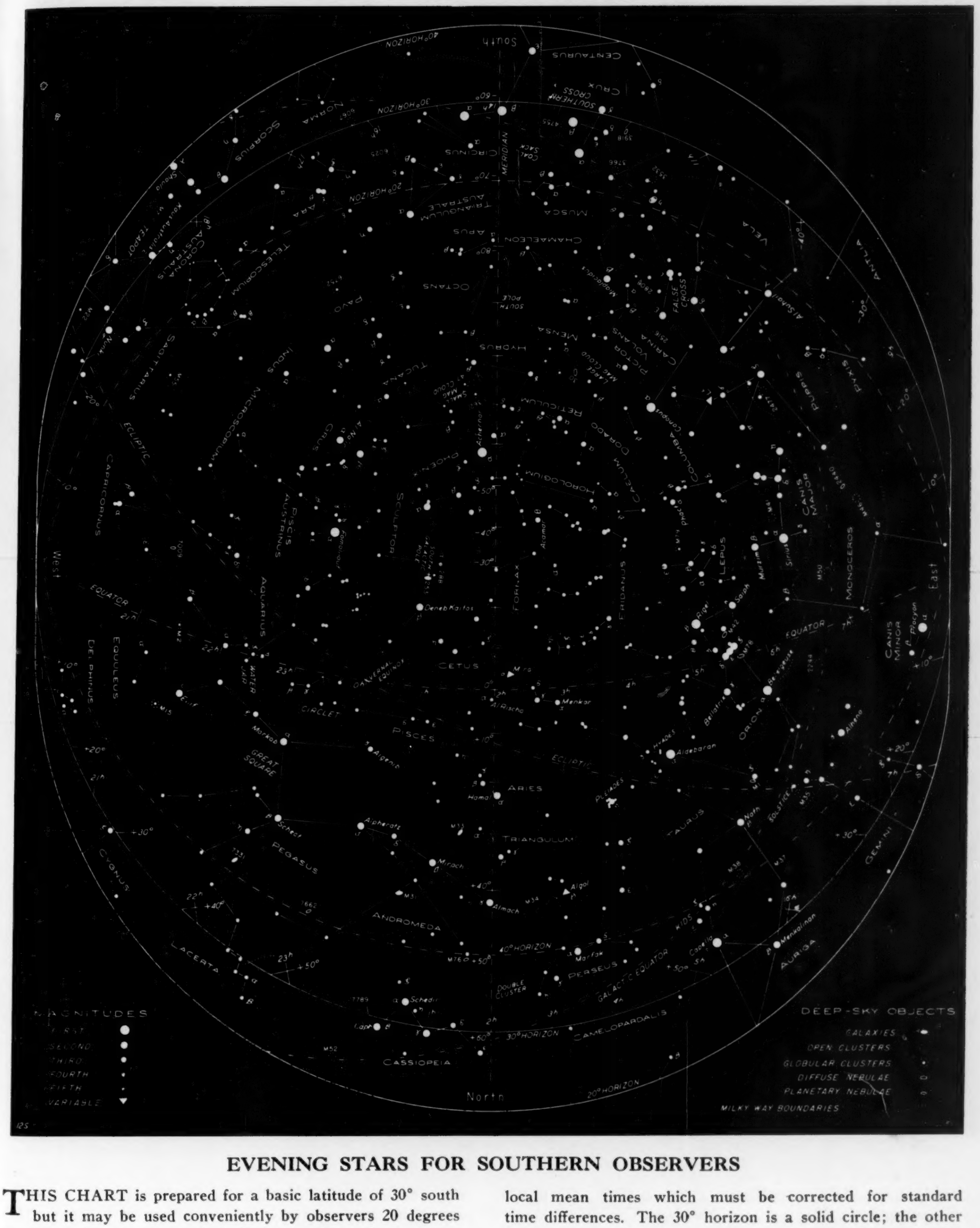
In order to appreciate the views in telescopes of 10 inches or more aperture, it is best to stop the driving clock and let the star fields drift at their own speed. After a 15- or 20-minute strip has passed, the telescope may be shifted to the next zone of declination. While this may sound tedious, it will reveal dozens of objects that no catalogue remarks upon — faint clusters, wisps of nebulosity, curious little streams of stars. The region around Gamma Cygni is especially interesting although the sweeps should extend as far as Albireo.

The AAVSO star charts (which may be purchased by non-members) will add specific interest to these regions, especially those for Cygnus variable stars SS, U, AF, ST and TU, Chi, and TZ Cygni. Another interesting occupation is to compare the plates of the Ross **Atlas** (for instance, see **Sky and Telescope,** back cover, August, 1945) against the views your own telescope affords.

WALTER SCOTT HOUSTON

STARS FOR SEPTEMBER

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m. local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. For the year 1948, these simplified charts replace our usual white-on-black maps, which may be consulted in issues of prior years when information on deep-sky wonders and less conspicuous constellations is desired. Our regular charts for observers in the Southern Hemisphere appear in alternate issues.



EVENING STARS FOR SOUTHERN OBSERVERS

THIS CHART is prepared for a basic latitude of 30° south but it may be used conveniently by observers 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance to allow time for transmission to observers in any part of the world. The sky is here shown as it appears on Nov. 7th at 11 p.m., Nov. 23rd at 10 p.m., Dec. 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly, four minutes earlier per day. These are local mean times which must be corrected for standard time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts. For other charts in this series, see alternate issues, October, 1946, to August, 1947; and November, 1947, to July, 1948.


TWO HUNDRED INCH MIRROR, CELL
SUPPORT & COVER
APPROXIMATE SCALE